MySQL NDB Cluster API Developer Guide

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This is the *MySQL NDB Cluster API Developer Guide*, which provides information about developing applications using NDB Cluster as a data store. Application interfaces covered in this Guide include the low-level C++-language *NDB API* for the MySQL `NDB` storage engine, the C-language *MGM API* for communicating with and controlling NDB Cluster management servers, and the *MySQL NDB Cluster Connector for Java*, which is a collection of Java APIs for writing applications against NDB Cluster, including JDBC, JPA, and ClusterJ.

NDB Cluster also provides support for the Memcache API; for more information, see Chapter 6, *ndbmemcache—Memcache API for NDB Cluster*.

NDB Cluster 7.3 and later also provides support for applications written using `Node.js`. See Chapter 5, *MySQL NoSQL Connector for JavaScript*, for more information.

This Guide includes concepts, terminology, class and function references, practical examples, common problems, and tips for using these APIs in applications.

For information about NDB internals that may be of interest to developers working with `NDB`, see MySQL NDB Cluster Internals Manual.

The information presented in this guide is current for recent releases of NDB Cluster up to and including NDB Cluster 8.0.20, now under development. Due to significant functional and other changes in NDB Cluster and its underlying APIs, you should not expect this information to apply to versions of the NDB Cluster software prior to NDB Cluster 7.3. Users of older NDB Cluster releases should upgrade to the latest available release of NDB Cluster 7.6, currently the most recent GA release series.

For more information about NDB 8.0, see What is New in NDB Cluster. For information regarding NDB 7.6, see What is New in NDB Cluster 7.6.

For help with using MySQL, please visit the MySQL Forums, where you can discuss your issues with other MySQL users.

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NDB Cluster also provides support for the Memcache API; for more information, see Chapter 6, *ndbmemcache—Memcache API for NDB Cluster*.

NDB Cluster 7.3 and later also provides support for applications written using `Node.js`. See Chapter 5, *MySQL NoSQL Connector for JavaScript*, for more information.

This Guide includes concepts, terminology, class and function references, practical examples, common problems, and tips for using these APIs in applications. It also contains information about NDB internals that may be of interest to developers working with `NDB`, such as communication protocols employed between nodes, file systems used by management nodes and data nodes, error messages, and debugging (`DUMP`) commands in the management client.

The information presented in this guide is current for recent releases of NDB Cluster up to and including NDB Cluster 8.0.20. Due to significant functional and other changes in NDB Cluster and its underlying APIs, you should not expect this information to apply to previous releases of the NDB Cluster software prior to NDB Cluster 7.3. Users of older NDB Cluster releases should upgrade to the latest available release of NDB Cluster 8.0, which is the most recent GA release series.

For more information about NDB 8.0, see What is New in NDB Cluster.

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Chapter 1 NDB Cluster APIs: Overview and Concepts

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This chapter provides a general overview of essential NDB Cluster, NDB API, and MGM API concepts, terminology, and programming constructs.

For an overview of Java APIs that can be used with NDB Cluster, see Section 4.1, “MySQL NDB Cluster Connector for Java: Overview”.

For information about using Memcache with NDB Cluster, see Chapter 6, *ndbmemcache—Memcache API for NDB Cluster*.

For information about writing JavaScript applications using Node.js with MySQL, see Chapter 5, *MySQL NoSQL Connector for JavaScript*.

1.1 NDB Cluster API Overview: Introduction

This section introduces the NDB Transaction and Scanning APIs as well as the NDB Management (MGM) API for use in building applications to run on NDB Cluster. It also discusses the general theory and principles involved in developing such applications.

1.1.1 NDB Cluster API Overview: The NDB API

The *NDB API* is an object-oriented application programming interface for NDB Cluster that implements indexes, scans, transactions, and event handling. NDB transactions are ACID-compliant in that they provide a means to group operations in such a way that they succeed (commit) or fail as a unit (rollback). It is also possible to perform operations in a “no-commit” or deferred mode, to be committed at a later time.

NDB scans are conceptually rather similar to the SQL cursors implemented in MySQL 5.0 and other common enterprise-level database management systems. These provide high-speed row processing for record retrieval purposes. (NDB Cluster naturally supports set processing just as does MySQL in its non-Cluster distributions. This can be accomplished through the usual MySQL APIs discussed in the MySQL Manual and elsewhere.) The NDB API supports both table scans and row scans; the latter can be performed using either unique or ordered indexes. Event detection and handling is discussed in Section 2.3.21, “The NdbEventOperation Class”, as well as Section 2.5.8, “NDB API Event Handling Example”.

In addition, the NDB API provides object-oriented error-handling facilities in order to provide a means of recovering gracefully from failed operations and other problems. (See Section 2.5.3, “NDB API Example: Handling Errors and Retrying Transactions”, for a detailed example.)

The NDB API provides a number of classes implementing the functionality described above. The most important of these include the `Ndb`, `Ndb_cluster_connection`, `NdbTransaction`, and `NdbOperation` classes. These model (respectively) database connections, cluster connections, transactions, and operations. These classes and their subclasses are listed in Section 2.3, “NDB API Classes, Interfaces, and Structures”. Error conditions in the NDB API are handled using `NdbError`.

Note

NDB API applications access the NDB Cluster's data store directly, without requiring a MySQL Server as an intermediary. This means that such applications are not bound by the MySQL privilege system; any NDB API application has read and write access to any `NDB` table stored in the same NDB Cluster at any time without restriction.

It is possible to distribute the MySQL grant tables, converting them from the default storage engine to `NDB`. Once this has been done, NDB API applications can access any of the MySQL grant tables. This means that such applications can read or write user names, passwords, and any other data stored in these tables.

1.1.2 NDB Cluster API Overview: The MGM API

The *NDB Cluster Management API*, also known as the *MGM API*, is a C-language programming interface intended to provide administrative services for the cluster. These include starting and stopping NDB Cluster nodes, handling NDB Cluster logging, backups, and restoration from backups, as well as various other management tasks. A conceptual overview of the MGM API and its uses can be found in Chapter 3, *The MGM API*.

The MGM API's principal structures model the states of individual modes (`ndb_mgm_node_state`), the state of the NDB Cluster as a whole (`ndb_mgm_cluster_state`), and management server response messages (`ndb_mgm_reply`). See Section 3.4, “MGM API Structures”, for detailed descriptions of these.

1.2 NDB Cluster API Overview: Terminology

This section provides a glossary of terms which are unique to the NDB and MGM APIs, or that have a specialized meaning when applied in the context of either or both of these APIs.

The terms in the following list are useful to an understanding of NDB Cluster, the NDB API, or have a specialized meaning when used in one of these:

Backup. A complete copy of all NDB Cluster data, transactions and logs, saved to disk.

Restore. Return the cluster to a previous state, as stored in a backup.

Checkpoint. Generally speaking, when data is saved to disk, it is said that a checkpoint has been reached. When working with the `NDB` storage engine, there are two sorts of checkpoints which work together in order to ensure that a consistent view of the cluster's data is maintained. These two types, *local checkpoints* and *global checkpoints*, are described in the next few paragraphs:

Local checkpoint (LCP). This is a checkpoint that is specific to a single node; however, LCPs take place for all nodes in the cluster more or less concurrently. An LCP involves saving all of a node's data to disk, and so usually occurs every few minutes, depending upon the amount of data stored by the node.

More detailed information about LCPs and their behavior can be found in the MySQL Manual; see in particular Defining NDB Cluster Data Nodes.

Global checkpoint (GCP). A GCP occurs every few seconds, when transactions for all nodes are synchronized and the REDO log is flushed to disk.

A related term is *GCI*, which stands for “Global Checkpoint ID”. This marks the point in the REDO log where a GCP took place.

Node. A component of NDB Cluster. 3 node types are supported:

- A *management (MGM) node* is an instance of `ndb_mgmd`, the NDB Cluster management server daemon.
- A *data node* an instance of `ndbd`, the NDB Cluster data storage daemon, and stores NDB Cluster data. This may also be an instance of `ndbmtd`, a multithreaded version of `ndbd`.
- An *API node*is an application that accesses NDB Cluster data. *SQL node* refers to a `mysqld` (MySQL Server) process that is connected to the NDB Cluster as an API node.

For more information about these node types, please refer to Section 1.3.3, “Review of NDB Cluster Concepts”, or to NDB Cluster Programs, in the *MySQL Manual*.

Node failure. An NDB Cluster is not solely dependent upon the functioning of any single node making up the cluster, which can continue to run even when one node fails.

Node restart. The process of restarting an NDB Cluster node which has stopped on its own or been stopped deliberately. This can be done for several different reasons, listed here:

- Restarting a node which has shut down on its own. (This is known as *forced shutdown* or *node failure*; the other cases discussed here involve manually shutting down the node and restarting it).
- To update the node's configuration.
- As part of a software or hardware upgrade.
- In order to defragment the node's `DataMemory`.

Initial node restart. The process of starting an NDB Cluster node with its file system having been removed. This is sometimes used in the course of software upgrades and in other special circumstances.

System crash (system failure). This can occur when so many data nodes have failed that the NDB Cluster's state can no longer be guaranteed.

System restart. The process of restarting an NDB Cluster and reinitializing its state from disk logs and checkpoints. This is required after any shutdown of the cluster, planned or unplanned.

Fragment. Contains a portion of a database table. In the `NDB` storage engine, a table is broken up into and stored as a number of subsets, usually referred to as fragments. A fragment is sometimes also called a *partition*.

Replica. Under the `NDB` storage engine, each table fragment has number of replicas in order to provide redundancy.

Transporter. A protocol providing data transfer across a network. The NDB API supports three different types of transporter connections: TCP/IP (local), TCP/IP (remote), and SHM. TCP/IP is, of course, the familiar network protocol that underlies HTTP, FTP, and so forth, on the Internet. SHM stands for Unix-style shared memory segments.

NDB. This originally stood for “Network DataBase”. It now refers to the MySQL storage engine (named `NDB` or `NDBCLUSTER`) used to enable the NDB Cluster distributed database system.

ACC (Access Manager). An NDB kernel block that handles hash indexes of primary keys providing speedy access to the records. For more information, see The DBACC Block.

TUP (Tuple Manager). This NDB kernel block handles storage of tuples (records) and contains the filtering engine used to filter out records and attributes when performing reads or updates. See The DBTUP Block, for more information.

TC (Transaction Coordinator). Handles coordination of transactions and timeouts in the NDB kernel (see The DBTC Block). Provides interfaces to the NDB API for performing indexes and scan operations.

For more information, see NDB Kernel Blocks, elsewhere in this *Guide*..

See also NDB Cluster Overview, in the *MySQL Manual*.

1.3 The NDB Transaction and Scanning API

This section discusses the high-level architecture of the NDB API, and introduces the NDB classes which are of greatest use and interest to the developer. It also covers most important NDB API concepts, including a review of NDB Cluster Concepts.

1.3.1 Core NDB API Classes

The NDB API is an NDB Cluster application interface that implements transactions. It consists of the following fundamental classes:

- `Ndb_cluster_connection` represents a connection to a cluster.
- `Ndb` is the main class, and represents a connection to a database.
- `NdbDictionary` provides meta-information about tables and attributes.
- `NdbTransaction` represents a transaction.
- `NdbOperation` represents an operation using a primary key.
- `NdbScanOperation` represents an operation performing a full table scan.
- `NdbIndexOperation` represents an operation using a unique hash index.
- `NdbIndexScanOperation` represents an operation performing a scan using an ordered index.
- `NdbRecAttr` represents an attribute value.

In addition, the NDB API defines an `NdbError` structure, which contains the specification for an error.

It is also possible to receive events triggered when data in the database is changed. This is accomplished through the `NdbEventOperation` class.

The `NDB` event notification API is not supported prior to MySQL 5.1.

For more information about these classes as well as some additional auxiliary classes not listed here, see Section 2.3, “NDB API Classes, Interfaces, and Structures”.

1.3.2 Application Program Basics

The main structure of an application program is as follows:

1. Connect to a cluster using the `Ndb_cluster_connection` object.
2. Initiate a database connection by constructing and initialising one or more `Ndb` objects.
3. Identify the tables, columns, and indexes on which you wish to operate, using `NdbDictionary` and one or more of its subclasses.
4. Define and execute transactions using the `NdbTransaction` class.
5. Delete `Ndb` objects.

6. Terminate the connection to the cluster (terminate an instance of `Ndb_cluster_connection`).

1.3.2.1 Using Transactions

The procedure for using transactions is as follows:

1. Start a transaction (instantiate an `NdbTransaction` object).
2. Add and define operations associated with the transaction using instances of one or more of the `NdbOperation`, `NdbScanOperation`, `NdbIndexOperation`, and `NdbIndexScanOperation` classes.
3. Execute the transaction (call `NdbTransaction::execute()`).
4. The operation can be of two different types—`Commit` or `NoCommit`:
   - If the operation is of type `NoCommit`, then the application program requests that the operation portion of a transaction be executed, but without actually committing the transaction. Following the execution of a `NoCommit` operation, the program can continue to define additional transaction operations for later execution.

     `NoCommit` operations can also be rolled back by the application.
   - If the operation is of type `Commit`, then the transaction is immediately committed. The transaction must be closed after it has been committed (even if the commit fails), and no further operations can be added to or defined for this transaction.

   See Section 2.3.30.5, “NdbTransaction::ExecType”.

1.3.2.2 Synchronous Transactions

Synchronous transactions are defined and executed as follows:

1. Begin (create) the transaction, which is referenced by an `NdbTransaction` object typically created using `Ndb::startTransaction()`. At this point, the transaction is merely being defined; it is not yet sent to the NDB kernel.
2. Define operations and add them to the transaction, using one or more of the following, along with the appropriate methods of the respective`NdbOperation` class (or possibly one or more of its subclasses):
   - `NdbTransaction::getNdbOperation()`
   - `NdbTransaction::getNdbScanOperation()`
   - `NdbTransaction::getNdbIndexOperation()`
   - `NdbTransaction::getNdbIndexScanOperation()`

   At this point, the transaction has still not yet been sent to the NDB kernel.
3. Execute the transaction, using the `NdbTransaction::execute()` method.
4. Close the transaction by calling `Ndb::closeTransaction()`.

For an example of this process, see Section 2.5.1, “NDB API Example Using Synchronous Transactions”.

To execute several synchronous transactions in parallel, you can either use multiple `Ndb` objects in several threads, or start multiple application programs.

1.3.2.3 Operations

An NdbTransaction consists of a list of operations, each of which is represented by an instance of NdbOperation, NdbScanOperation, NdbIndexOperation, or NdbIndexScanOperation (that is, of NdbOperation or one of its child classes).

See NDB Access Types, for general information about NDB Cluster access operation types.

NDB Access Types

The data node process has a number of simple constructs which are used to access the data in an NDB Cluster. We have created a very simple benchmark to check the performance of each of these.

There are four access methods:

- **Primary key access.** This is access of a record through its primary key. In the simplest case, only one record is accessed at a time, which means that the full cost of setting up a number of TCP/IP messages and a number of costs for context switching are borne by this single request. In the case where multiple primary key accesses are sent in one batch, those accesses share the cost of setting up the necessary TCP/IP messages and context switches. If the TCP/IP messages are for different destinations, additional TCP/IP messages need to be set up.

- **Unique key access.** Unique key accesses are similar to primary key accesses, except that a unique key access is executed as a read on an index table followed by a primary key access on the table. However, only one request is sent from the MySQL Server, and the read of the index table is handled by the data node. Such requests also benefit from batching.

- **Full table scan.** When no indexes exist for a lookup on a table, a full table scan is performed. This is sent as a single request to the ndbd process, which then divides the table scan into a set of parallel scans on all NDB data node processes.

- **Range scan using ordered index.** When an ordered index is used, it performs a scan in the same manner as the full table scan, except that it scans only those records which are in the range used by the query transmitted by the MySQL server (SQL node). All partitions are scanned in parallel when all bound index attributes include all attributes in the partitioning key.

Single-row operations

After the operation is created using NdbTransaction::getNdbOperation() or NdbTransaction::getNdbIndexOperation(), it is defined in the following three steps:

1. Specify the standard operation type using NdbOperation::readTuple().

2. Specify search conditions using NdbOperation::equal().

3. Specify attribute actions using NdbOperation::getValue().

Here are two brief examples illustrating this process. For the sake of brevity, we omit error handling.

This first example uses an NdbOperation:

```
// 1. Retrieve table object
myTable= myDict->getTable("MYTABLENAME");

// 2. Create an NdbOperation on this table
myOperation= myTransaction->getNdbOperation(myTable);

// 3. Define the operation's type and lock mode
myOperation->readTuple(NdbOperation::LM_Read);

// 4. Specify search conditions
myOperation->equal("ATTR1", i);

// 5. Perform attribute retrieval
myRecAttr= myOperation->getValue("ATTR2", NULL);
```

For additional examples of this sort, see Section 2.5.1, “NDB API Example Using Synchronous Transactions”.

The second example uses an `NdbIndexOperation`:

```
// 1. Retrieve index object
myIndex= myDict->getIndex("MYINDEX", "MYTABLENAME");

// 2. Create
myOperation= myTransaction->getNdbIndexOperation(myIndex);

// 3. Define type of operation and lock mode
myOperation->readTuple(NdbOperation::LM_Read);

// 4. Specify Search Conditions
myOperation->equal("ATTR1", i);

// 5. Attribute Actions
myRecAttr = myOperation->getValue("ATTR2", NULL);
```

Another example of this second type can be found in Section 2.5.5, “NDB API Example: Using Secondary Indexes in Scans”.

We now discuss in somewhat greater detail each step involved in the creation and use of synchronous transactions.

1. **Define single row operation type.** The following operation types are supported:

   - `NdbOperation::insertTuple()`: Inserts a nonexisting tuple.
   - `NdbOperation::writeTuple()`: Updates a tuple if one exists, otherwise inserts a new tuple.
   - `NdbOperation::updateTuple()`: Updates an existing tuple.
   - `NdbOperation::deleteTuple()`: Deletes an existing tuple.
   - `NdbOperation::readTuple()`: Reads an existing tuple using the specified lock mode.

   All of these operations operate on the unique tuple key. When `NdbIndexOperation` is used, then each of these operations operates on a defined unique hash index.

   Note

   If you want to define multiple operations within the same transaction, then you need to call `NdbTransaction::getNdbOperation()` or `NdbTransaction::getNdbIndexOperation()` for each operation.

2. **Specify Search Conditions.** The search condition is used to select tuples. Search conditions are set using `NdbOperation::equal()`.

3. **Specify Attribute Actions.** Next, it is necessary to determine which attributes should be read or updated. It is important to remember that:

   - Deletes can neither read nor set values, but only delete them.
   - Reads can only read values.
   - Updates can only set values. Normally the attribute is identified by name, but it is also possible to use the attribute's identity to determine the attribute.

   `NdbOperation::getValue()` returns an `NdbRecAttr` object containing the value as read. To obtain the actual value, one of two methods can be used; the application can either

   - Use its own memory (passed through a pointer *aValue*) to `NdbOperation::getValue()`, or

- receive the attribute value in an `NdbRecAttr` object allocated by the NDB API.

The `NdbRecAttr` object is released when `Ndb::closeTransaction()` is called. For this reason, the application cannot reference this object following any subsequent call to `Ndb::closeTransaction()`. Attempting to read data from an `NdbRecAttr` object before calling `NdbTransaction::execute()` yields an undefined result.

Scan Operations

Scans are roughly the equivalent of SQL cursors, providing a means to perform high-speed row processing. A scan can be performed on either a table (using an `NdbScanOperation`) or an ordered index (by means of an `NdbIndexScanOperation`).

Scan operations have the following characteristics:

- They can perform read operations which may be shared, exclusive, or dirty.
- They can potentially work with multiple rows.
- They can be used to update or delete multiple rows.
- They can operate on several nodes in parallel.

After the operation is created using `NdbTransaction::getNdbScanOperation()` or `NdbTransaction::getNdbIndexScanOperation()`, it is carried out as follows:

1. Define the standard operation type, using `NdbScanOperation::readTuples()`.

   Note

   See Section 2.3.29.7, “NdbScanOperation::readTuples()”, for additional information about deadlocks which may occur when performing simultaneous, identical scans with exclusive locks.

2. Specify search conditions, using `NdbScanFilter`, `NdbIndexScanOperation::setBound()`, or both.
3. Specify attribute actions using `NdbOperation::getValue()`.
4. Execute the transaction using `NdbTransaction::execute()`.
5. Traverse the result set by means of successive calls to `NdbScanOperation::nextResult()`.

Here are two brief examples illustrating this process. Once again, in order to keep things relatively short and simple, we forego any error handling.

This first example performs a table scan using an `NdbScanOperation`:

```
// 1. Retrieve a table object
myTable= myDict->getTable("MYTABLENAME");

// 2. Create a scan operation (NdbScanOperation) on this table
myOperation= myTransaction->getNdbScanOperation(myTable);

// 3. Define the operation's type and lock mode
myOperation->readTuples(NdbOperation::LM_Read);

// 4. Specify search conditions
NdbScanFilter sf(myOperation);
sf.begin(NdbScanFilter::OR);
sf.eq(0, i);   // Return rows with column 0 equal to i or
sf.eq(1, i+1); // column 1 equal to (i+1)
sf.end();
```

```
// 5. Retrieve attributes
myRecAttr= myOperation->getValue("ATTR2", NULL);
```

The second example uses an `NdbIndexScanOperation` to perform an index scan:

```
// 1. Retrieve index object
myIndex= myDict->getIndex("MYORDEREDINDEX", "MYTABLENAME");

// 2. Create an operation (NdbIndexScanOperation object)
myOperation= myTransaction->getNdbIndexScanOperation(myIndex);

// 3. Define type of operation and lock mode
myOperation->readTuples(NdbOperation::LM_Read);

// 4. Specify search conditions
// All rows with ATTR1 between i and (i+1)
myOperation->setBound("ATTR1", NdbIndexScanOperation::BoundGE, i);
myOperation->setBound("ATTR1", NdbIndexScanOperation::BoundLE, i+1);

// 5. Retrieve attributes
myRecAttr = MyOperation->getValue("ATTR2", NULL);
```

Some additional discussion of each step required to perform a scan follows:

1. **Define Scan Operation Type.** It is important to remember that only a single operation is supported for each scan operation (`NdbScanOperation::readTuples()` or `NdbIndexScanOperation::readTuples()`).

   Note

   If you want to define multiple scan operations within the same transaction, then you need to call `NdbTransaction::getNdbScanOperation()` or `NdbTransaction::getNdbIndexScanOperation()` separately for *each* operation.

2. **Specify Search Conditions.** The search condition is used to select tuples. If no search condition is specified, the scan will return all rows in the table. The search condition can be an `NdbScanFilter` (which can be used on both `NdbScanOperation` and `NdbIndexScanOperation`) or bounds (which can be used only on index scans - see `NdbIndexScanOperation::setBound()`). An index scan can use both `NdbScanFilter` and bounds.

   Note

   When NdbScanFilter is used, each row is examined, whether or not it is actually returned. However, when using bounds, only rows within the bounds will be examined.

3. **Specify Attribute Actions.** Next, it is necessary to define which attributes should be read. As with transaction attributes, scan attributes are defined by name, but it is also possible to use the attributes' identities to define attributes as well. As discussed elsewhere in this document (see Section 1.3.2.2, "Synchronous Transactions"), the value read is returned by the `NdbOperation::getValue()` method as an `NdbRecAttr` object.

Using Scans to Update or Delete Rows

Scanning can also be used to update or delete rows. This is performed as follows:

1. Scanning with exclusive locks using `NdbOperation::LM_Exclusive`.

2. (*When iterating through the result set*:) For each row, optionally calling either `NdbScanOperation::updateCurrentTuple()` or `NdbScanOperation::deleteCurrentTuple()`.

3. (*If performing* `NdbScanOperation::updateCurrentTuple()`:) Setting new values for records simply by using `NdbOperation::setValue()`. `NdbOperation::equal()` should not be called in such cases, as the primary key is retrieved from the scan.

> **Important**
>
> The update or delete is not actually performed until the next call to `NdbTransaction::execute()` is made, just as with single row operations. `NdbTransaction::execute()` also must be called before any locks are released; for more information, see Lock Handling with Scans.

Features Specific to Index Scans. When performing an index scan, it is possible to scan only a subset of a table using `NdbIndexScanOperation::setBound()`. In addition, result sets can be sorted in either ascending or descending order, using `NdbIndexScanOperation::readTuples()`. Note that rows are returned unordered by default unless *`sorted`* is set to `true`.

It is also important to note that, when using `NdbIndexScanOperation::BoundEQ` (see Section 2.3.23.1, "NdbIndexScanOperation::BoundType") with a partition key, only fragments containing rows will actually be scanned. Finally, when performing a sorted scan, any value passed as the `NdbIndexScanOperation::readTuples()` method's *`parallel`* argument will be ignored and maximum parallelism will be used instead. In other words, all fragments which it is possible to scan are scanned simultaneously and in parallel in such cases.

Lock Handling with Scans

Performing scans on either a table or an index has the potential to return a great many records; however, Ndb locks only a predetermined number of rows per fragment at a time. The number of rows locked per fragment is controlled by the batch parameter passed to `NdbScanOperation::readTuples()`.

In order to enable the application to handle how locks are released, `NdbScanOperation::nextResult()` has a Boolean parameter *`fetchAllowed`*. If `NdbScanOperation::nextResult()` is called with *`fetchAllowed`* equal to `false`, then no locks may be released as result of the function call. Otherwise the locks for the current batch may be released.

This next example shows a scan delete that handles locks in an efficient manner. For the sake of brevity, we omit error-handling.

```
int check;

// Outer loop for each batch of rows
while((check = MyScanOperation->nextResult(true)) == 0)
{
  do
  {
    // Inner loop for each row within the batch
    MyScanOperation->deleteCurrentTuple();
  }
  while((check = MyScanOperation->nextResult(false)) == 0);

  // When there are no more rows in the batch, execute all defined deletes
  MyTransaction->execute(NoCommit);
}
```

For a more complete example of a scan, see Section 2.5.4, "NDB API Basic Scanning Example".

Error Handling

Errors can occur either when operations making up a transaction are being defined, or when the transaction is actually being executed. Catching and handling either sort of error requires testing the value returned by `NdbTransaction::execute()`, and then, if an error is indicated (that is, if this value is equal to `-1`), using the following two methods in order to identify the error's type and location:

- `NdbTransaction::getNdbErrorOperation()` returns a reference to the operation causing the most recent error.
- `NdbTransaction::getNdbErrorLine()` yields the method number of the erroneous method in the operation, starting with `1`.

This short example illustrates how to detect an error and to use these two methods to identify it:

```
theTransaction = theNdb->startTransaction();
theOperation = theTransaction->getNdbOperation("TEST_TABLE");
if(theOperation == NULL)
  goto error;

theOperation->readTuple(NdbOperation::LM_Read);
theOperation->setValue("ATTR_1", at1);
theOperation->setValue("ATTR_2", at1);  //  Error occurs here
theOperation->setValue("ATTR_3", at1);
theOperation->setValue("ATTR_4", at1);

if(theTransaction->execute(Commit) == -1)
{
  errorLine = theTransaction->getNdbErrorLine();
  errorOperation = theTransaction->getNdbErrorOperation();
}
```

Here, `errorLine` is `3`, as the error occurred in the third method called on the `NdbOperation` object (in this case, `theOperation`). If the result of `NdbTransaction::getNdbErrorLine()` is `0`, then the error occurred when the operations were executed. In this example, `errorOperation` is a pointer to the object `theOperation`. The `NdbTransaction::getNdbError()` method returns an `NdbError` object providing information about the error.

Note

Transactions are *not* automatically closed when an error occurs. You must call `Ndb::closeTransaction()` or `NdbTransaction::close()` to close the transaction.

See Section 2.3.16.2, "Ndb::closeTransaction()", and Section 2.3.30.1, "NdbTransaction::close()".

One recommended way to handle a transaction failure (that is, when an error is reported) is as shown here:

1. Roll back the transaction by calling `NdbTransaction::execute()` with a special `ExecType` value for the *`type`* parameter.

   See Section 2.3.30.6, "NdbTransaction::execute()" and Section 2.3.30.5, "NdbTransaction::ExecType", for more information about how this is done.

2. Close the transaction by calling `NdbTransaction::close()`.
3. If the error was temporary, attempt to restart the transaction.

Several errors can occur when a transaction contains multiple operations which are simultaneously executed. In this case the application must go through all operations and query each of their `NdbError` objects to find out what really happened.

Important

Errors can occur even when a commit is reported as successful. In order to handle such situations, the NDB API provides an additional `NdbTransaction::commitStatus()` method to check the transaction's commit status.

See Section 2.3.30.2, "NdbTransaction::commitStatus()".

1.3.3 Review of NDB Cluster Concepts

This section covers the NDB Kernel, and discusses NDB Cluster transaction handling and transaction coordinators. It also describes NDB record structures and concurrency issues.

The *NDB Kernel* is the collection of data nodes belonging to an NDB Cluster. The application programmer can for most purposes view the set of all storage nodes as a single entity. Each data node is made up of three main components:

- **TC**: The transaction coordinator.
- **ACC**: The index storage component.
- **TUP**: The data storage component.

When an application executes a transaction, it connects to one transaction coordinator on one data node. Usually, the programmer does not need to specify which TC should be used, but in some cases where performance is important, the programmer can provide “hints” to use a certain TC. (If the node with the desired transaction coordinator is down, then another TC will automatically take its place.)

Each data node has an ACC and a TUP which store the indexes and data portions of the database table fragment. Even though a single TC is responsible for the transaction, several ACCs and TUPs on other data nodes might be involved in that transaction's execution.

1.3.3.1 Selecting a Transaction Coordinator

The default method is to select the transaction coordinator (TC) determined to be the "nearest" data node, using a heuristic for proximity based on the type of transporter connection. In order of nearest to most distant, these are:

1. SHM
2. TCP/IP (localhost)
3. TCP/IP (remote host)

If there are several connections available with the same proximity, one is selected for each transaction in a round-robin fashion. Optionally, you may set the method for TC selection to round-robin mode, where each new set of transactions is placed on the next data node. The pool of connections from which this selection is made consists of all available connections.

As noted in Section 1.3.3, “Review of NDB Cluster Concepts”, the application programmer can provide hints to the NDB API as to which transaction coordinator should be uses. This is done by providing a table and a partition key (usually the primary key). If the primary key is the partition key, then the transaction is placed on the node where the primary replica of that record resides. Note that this is only a hint; the system can be reconfigured at any time, in which case the NDB API chooses a transaction coordinator without using the hint. For more information, see Column::getPartitionKey(), and Section 2.3.16.35, “Ndb::startTransaction()”.

The application programmer can specify the partition key from SQL by using the following construct:

```
CREATE TABLE ... ENGINE=NDB PARTITION BY KEY (attribute_list);
```

For additional information, see Partitioning, and in particular KEY Partitioning, in the MySQL Manual.

1.3.3.2 NDB Record Structure

The `NDB` storage engine used by NDB Cluster is a relational database engine storing records in tables as with other relational database systems. Table rows represent records as tuples of relational data. When a new table is created, its attribute schema is specified for the table as a whole, and thus each table row has the same structure. Again, this is typical of relational databases, and NDB is no different in this regard.

Primary Keys. Each record has from 1 up to 32 attributes which belong to the primary key of the table.

Transactions. Transactions are committed first to main memory, and then to disk, after a global checkpoint (GCP) is issued. Since all data are (in most NDB Cluster configurations) synchronously replicated and stored on multiple data nodes, the system can handle processor failures without loss of data. However, in the case of a system-wide failure, all transactions (committed or not) occurring since the most recent GCP are lost.

Concurrency Control.
NDB uses *pessimistic concurrency control* based on locking. If a requested lock (implicit and depending on database operation) cannot be attained within a specified time, then a timeout error results.

Concurrent transactions as requested by parallel application programs and thread-based applications can sometimes deadlock when they try to access the same information simultaneously. Thus, applications need to be written in a manner such that timeout errors occurring due to such deadlocks are handled gracefully. This generally means that the transaction encountering a timeout should be rolled back and restarted.

Hints and Performance.
Placing the transaction coordinator in close proximity to the actual data used in the transaction can in many cases improve performance significantly. This is particularly true for systems using TCP/IP. For example, a Solaris system using a single 500 MHz processor has a cost model for TCP/IP communication which can be represented by the formula

```
[30 microseconds] + ([100 nanoseconds] * [number of bytes])
```

This means that if we can ensure that we use “popular” links we increase buffering and thus drastically reduce the costs of communication.

A simple example would be an application that uses many simple updates where a transaction needs to update one record. This record has a 32-bit primary key which also serves as the partitioning key. Then the `keyData` is used as the address of the integer of the primary key and `keyLen` is `4`.

1.3.4 The Adaptive Send Algorithm

Discusses the mechanics of transaction handling and transmission in NDB Cluster and the NDB API, and the objects used to implement these.

When transactions are sent using `NdbTransaction::execute()`, they are not immediately transferred to the NDB Kernel. Instead, transactions are kept in a special send list (buffer) in the `Ndb` object to which they belong. The adaptive send algorithm decides when transactions should actually be transferred to the NDB kernel.

The NDB API is designed as a multithreaded interface, and so it is often desirable to transfer database operations from more than one thread at a time. The NDB API keeps track of which `Ndb` objects are active in transferring information to the NDB kernel and the expected number of threads to interact with the NDB kernel. Note that a given instance of `Ndb` should be used in at most one thread; different threads should *not* share the same `Ndb` object.

There are four conditions leading to the transfer of database operations from `Ndb` object buffers to the NDB kernel:

1. The NDB Transporter (TCP/IP or shared memory) decides that a buffer is full and sends it off. The buffer size is implementation-dependent and may change between NDB Cluster releases. When TCP/IP is the transporter, the buffer size is usually around 64 KB. Since each `Ndb` object provides a single buffer per data node, the notion of a “full” buffer is local to each data node.

2. The accumulation of statistical data on transferred information may force sending of buffers to all storage nodes (that is, when all the buffers become full).

3. Every 10 milliseconds, a special transmission thread checks whether or not any send activity has occurred. If not, then the thread will force transmission to all nodes. This means that 20 ms is the maximum amount of time that database operations are kept waiting before being dispatched. A 10-millisecond limit is likely in future releases of NDB Cluster; checks more frequent than this require additional support from the operating system.

4. For methods that are affected by the adaptive send algorithm (such as `NdbTransaction::execute()`), there is a *`force`* parameter that overrides its default behavior in this regard and forces immediate transmission to all nodes. See the individual NDB API class listings for more information.

The conditions listed above are subject to change in future releases of NDB Cluster.

Chapter 2 The NDB API

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This chapter contains information about the NDB API, which is used to write applications that access data in the `NDB` storage engine.

2.1 Getting Started with the NDB API

This section discusses preparations necessary for writing and compiling an NDB API application.

2.1.1 Compiling and Linking NDB API Programs

This section provides information on compiling and linking NDB API applications, including requirements and compiler and linker options.

2.1.1.1 General Requirements

To use the NDB API with MySQL, you must have the `libndbclient` client library and its associated header files installed alongside the regular MySQL client libraries and headers. These are automatically installed when you build MySQL using `-DWITH_NDBCLUSTER=ON` or use a MySQL binary package that supports the `NDB` storage engine.

This *Guide* is targeted for use with MySQL NDB Cluster 7.3 and later.

2.1.1.2 Compiler Options

Header Files. In order to compile source files that use the NDB API, you must ensure that the necessary header files can be found. Header files specific to the NDB and MGM APIs are installed in the following subdirectories of the MySQL `include` directory, respectively:

- `include/mysql/storage/ndb/ndbapi`
- `include/mysql/storage/ndb/mgmapi`

Compiler Flags. The MySQL-specific compiler flags needed can be determined using the `mysql_config` utility that is part of the MySQL installation:

```
$ mysql_config --cflags
-I/usr/local/mysql/include/mysql -Wreturn-type -Wtrigraphs -W -Wformat
-Wsign-compare -Wunused  -mcpu=pentium4 -march=pentium4
```

This sets the include path for the MySQL header files but not for those specific to the NDB API. The `--include` option to `mysql_config` returns the generic include path switch:

```
shell> mysql_config --include
-I/usr/local/mysql/include/mysql
```

It is necessary to add the subdirectory paths explicitly, so that adding all the needed compile flags to the `CXXFLAGS` shell variable should look something like this:

```
CFLAGS="$CFLAGS "`mysql_config --cflags`
CFLAGS="$CFLAGS "`mysql_config --include`/storage/ndb
CFLAGS="$CFLAGS "`mysql_config --include`/storage/ndb/ndbapi
CFLAGS="$CFLAGS "`mysql_config --include`/storage/ndb/mgmapi
```

Tip

If you do not intend to use the NDB Cluster management functions, the last line in the previous example can be omitted. However, if you are interested in the management functions only, and do not want or need to access NDB Cluster data except from MySQL, then you can omit the line referencing the `ndbapi` directory.

2.1.1.3 Linker Options

NDB API applications must be linked against both the MySQL and `NDB` client libraries. The `NDB` client library also requires some functions from the `mystrings` library, so this must be linked in as well.

The necessary linker flags for the MySQL client library are returned by `mysql_config --libs`. For multithreaded applications you should use the `--libs_r` instead:

```
$ mysql_config --libs_r
-L/usr/local/mysql-5.1/lib/mysql -lmysqlclient_r -lz -lpthread -lcrypt
-lnsl -lm -lpthread -L/usr/lib -lssl -lcrypto
```

It is now necessary only to add `-lndbclient` to `LD_FLAGS`, as shown here:

```
LDFLAGS="$LDFLAGS "`mysql_config --libs_r`
LDFLAGS="$LDFLAGS -lndbclient"
```

2.1.1.4 Using Autotools

It is often faster and simpler to use GNU autotools than to write your own makefiles. In this section, we provide an `autoconf` macro `WITH_MYSQL` that can be used to add a `--with-mysql` option to a configure file, and that automatically sets the correct compiler and linker flags for given MySQL installation.

All of the examples in this chapter include a common `mysql.m4` file defining `WITH_MYSQL`. A typical complete example consists of the actual source file and the following helper files:

- `acinclude`
- `configure.in`
- `Makefile.m4`

`automake` also requires that you provide `README`, `NEWS`, `AUTHORS`, and `ChangeLog` files; however, these can be left empty.

To create all necessary build files, run the following:

```
aclocal
autoconf
automake -a -c
configure --with-mysql=/mysql/prefix/path
```

Normally, this needs to be done only once, after which `make` will accommodate any file changes.

Example 1-1: acinclude.m4.

```
m4_include([../mysql.m4])
```

Example 1-2: configure.in.

```
AC_INIT(example, 1.0)
```

```
AM_INIT_AUTOMAKE(example, 1.0)
WITH_MYSQL()
AC_OUTPUT(Makefile)
```

Example 1-3: Makefile.am.

```
bin_PROGRAMS = example
example_SOURCES = example.cc
```

Example 1-4: WITH_MYSQL source for inclusion in acinclude.m4.

```
dnl
dnl configure.in helper macros
dnl

AC_DEFUN([WITH_MYSQL], [
  AC_MSG_CHECKING(for mysql_config executable)

  AC_ARG_WITH(mysql, [  --with-mysql=PATH path to mysql_config binary or mysql prefix dir], [
  if test -x $withval -a -f $withval
    then
      MYSQL_CONFIG=$withval
    elif test -x $withval/bin/mysql_config -a -f $withval/bin/mysql_config
    then
     MYSQL_CONFIG=$withval/bin/mysql_config
    fi
  ], [
  if test -x /usr/local/mysql/bin/mysql_config -a -f /usr/local/mysql/bin/mysql_config
    then
      MYSQL_CONFIG=/usr/local/mysql/bin/mysql_config
    elif test -x /usr/bin/mysql_config -a -f /usr/bin/mysql_config
    then
      MYSQL_CONFIG=/usr/bin/mysql_config
    fi
  ])

  if test "x$MYSQL_CONFIG" = "x"
  then
    AC_MSG_RESULT(not found)
    exit 3
  else
    AC_PROG_CC
    AC_PROG_CXX

    # add regular MySQL C flags
    ADDFLAGS=`$MYSQL_CONFIG --cflags`

    # add NDB API specific C flags
    IBASE=`$MYSQL_CONFIG --include`
    ADDFLAGS="$ADDFLAGS $IBASE/storage/ndb"
    ADDFLAGS="$ADDFLAGS $IBASE/storage/ndb/ndbapi"
    ADDFLAGS="$ADDFLAGS $IBASE/storage/ndb/mgmapi"

    CFLAGS="$CFLAGS $ADDFLAGS"
    CXXFLAGS="$CXXFLAGS $ADDFLAGS"

    LDFLAGS="$LDFLAGS "`$MYSQL_CONFIG --libs_r`" -lndbclient -lmystrings -lmysys"
    LDFLAGS="$LDFLAGS "`$MYSQL_CONFIG --libs_r`" -lndbclient -lmystrings"

    AC_MSG_RESULT($MYSQL_CONFIG)
  fi
])
```

2.1.2 Connecting to the Cluster

This section covers connecting an NDB API application to an NDB Cluster.

2.1.2.1 Include Files

NDB API applications require one or more of the following include files:

- Applications accessing NDB Cluster data using the NDB API must include the file `NdbApi.hpp`.
- Applications making use of the regular MySQL client API as well as the NDB API must also include `mysql.h` (in addition to `NdbApi.hpp`).
- Applications that use NDB Cluster management functions from the MGM API need the include file `mgmapi.h`.

2.1.2.2 API Initialization and Cleanup

Before using the NDB API, it must first be initialized by calling the `ndb_init()` function.

Once an NDB API application is complete, you can call `ndb_end(0)` to perform any necessary cleanup. Keep in mind that, before you invoke this function, all `Ndb_cluster_connection` objects created in your NDB API application must be cleaned up or destroyed; otherwise, threads created when an `Ndb_cluster_connection` object's `connect()` method is invoked do not exit properly, which causes errors on application termination. When an `Ndb_cluster_connection` is created statically, you must not call `ndb_end()` in the same scope as the connection object. When the connection object is created dynamically, you can destroy it using `delete()` before calling `ndb_end()`.

Each of the functions `ndb_init()` and `ndb_end()` is defined in the file `storage/ndb/include/ndb_init.h`.

Note

It should be possible to use `fork()` in NDB API applications, but you must do so prior to calling `ndb_init()` or `my_init()` to avoid sharing of resources such as files and connections between processes.

2.1.2.3 Establishing the Connection

To establish a connection to the server, you must create an instance of `Ndb_cluster_connection`, whose constructor takes as its argument a cluster connection string. If no connection string is given, `localhost` is assumed.

The cluster connection is not actually initiated until the `Ndb_cluster_connection::connect()` method is called. When invoked without any arguments, the connection attempt is retried indefinitely, once per second, until successful. No reporting is done until the connection has been made.

By default an API node connects to the “nearest” data node. This is usually a data node running on the same machine as the nearest, due to the fact that shared memory transport can be used instead of the slower TCP/IP. This may lead to poor load distribution in some cases, so it is possible to enforce a round-robin node connection scheme by calling the `set_optimized_node_selection()` method with `0` as its argument prior to calling `connect()`.

`connect()` initiates a connection to an NDB Cluster management node only. To enable connections with data nodes, use `wait_until_ready()` after calling `connect()`; `wait_until_ready()` waits up to a given number of seconds for a connection to a data node to be established.

In the following example, initialization and connection are handled in the two functions `example_init()` and `example_end()`, which are included in subsequent examples by means of including the file `example_connection.h`.

Example 2-1: Connection example.

```
#include <stdio.h>
#include <stdlib.h>
#include <NdbApi.hpp>
#include <mysql.h>
#include <mgmapi.h>
```

```
Ndb_cluster_connection* connect_to_cluster();
void disconnect_from_cluster(Ndb_cluster_connection *c);

Ndb_cluster_connection* connect_to_cluster()
{
  Ndb_cluster_connection* c;

  if(ndb_init())
    exit(EXIT_FAILURE);

  c= new Ndb_cluster_connection();

  if(c->connect(4, 5, 1))
  {
    fprintf(stderr, "Unable to connect to cluster within 30 seconds.\n\n");
    exit(EXIT_FAILURE);
  }

  if(c->wait_until_ready(30, 0) < 0)
  {
    fprintf(stderr, "Cluster was not ready within 30 seconds.\n\n");
    exit(EXIT_FAILURE);
  }

  return c;
}

void disconnect_from_cluster(Ndb_cluster_connection *c)
{
  delete c;

  ndb_end(2);
}

int main(int argc, char* argv[])
{
  Ndb_cluster_connection *ndb_connection= connect_to_cluster();

  printf("Connection Established.\n\n");

  disconnect_from_cluster(ndb_connection);

  return EXIT_SUCCESS;
}
```

2.1.3 Mapping MySQL Database Object Names and Types to NDB

The next two sections discuss naming and other conventions followed by the NDB API with regard to MySQL database objects, as well as handling of MySQL data types in NDB API applications.

2.1.3.1 MySQL Database Object Names in the NDB API

This section discusses mapping of MySQL database objects to the NDB API.

Databases and Schemas. Databases and schemas are not represented by objects as such in the NDB API. Instead, they are modelled as attributes of `Table` and `Index` objects. The value of the `database` attribute of one of these objects is always the same as the name of the MySQL database to which the table or index belongs. The value of the `schema` attribute of a `Table` or `Index` object is always '`def`' (for “default”).

Tables. MySQL table names are directly mapped to `NDB` table names without modification. Table names starting with '`NDB$`' are reserved for internal use, as is the `SYSTAB_0` table in the `sys` database.

Indexes. There are two different type of NDB indexes:

- *Hash indexes* are unique, but not ordered.

- *B-tree indexes* are ordered, but permit duplicate values.

Names of unique indexes and primary keys are handled as follows:

- For a MySQL UNIQUE index, both a B-tree and a hash index are created. The B-tree index uses the MySQL name for the index; the name for the hash index is generated by appending '$unique' to the index name.
- For a MySQL primary key only a B-tree index is created. This index is given the name PRIMARY. There is no extra hash; however, the uniqueness of the primary key is guaranteed by making the MySQL key the internal primary key of the NDB table.

Column Names and Values. NDB column names are the same as their MySQL names.

2.1.3.2 NDB API Handling of MySQL Data Types

This section provides information about the way in which MySQL data types are represented in NDBCLUSTER table columns and how these values can be accessed in NDB API applications.

Numeric data types. The MySQL TINYINT, SMALLINT, INT, and BIGINT data types map to NDB types having the same names and storage requirements as their MySQL counterparts.

The MySQL FLOAT and DOUBLE data types are mapped to NDB types having the same names and storage requirements.

Data types used for character data. The storage space required for a MySQL CHAR column is determined by the maximum number of characters and the column's character set. For most (but not all) character sets, each character takes one byte of storage. When using utf8, each character requires three bytes; utfmb4 uses up to four bytes per character. You can find the maximum number of bytes needed per character in a given character set by checking the Maxlen column in the output of SHOW CHARACTER SET.

An NDB VARCHAR column value maps to a MySQL VARCHAR, except that the first two bytes of the NDB VARCHAR are reserved for the length of the string. A utility function like that shown here can make a VARCHAR value ready for use in an NDB API application:

```
void make_ndb_varchar(char *buffer, char *str)
{
  int len = strlen(str);
  int hlen = (len > 255) ? 2 : 1;
  buffer[0] = len & 0xff;
  if( len > 255 )
    buffer[1] = (len / 256);
  strcpy(buffer+hlen, str);
}
```

You can use this function as shown here:

```
char myVal[128+1]; // Size of myVal (+1 for length)
...
make_ndb_varchar(myVal, "NDB is way cool!!");
myOperation->setValue("myVal", myVal);
```

See Section 2.5.11, “NDB API Simple Array Example”, for a complete example program that writes and reads VARCHAR and VARBINARY values to and from a table using the NDB API.

MySQL storage requirements for a VARCHAR or VARBINARY column depend on whether the column is stored in memory or on disk:

- For in-memory columns, the NDB storage engine supports variable-width columns with 4-byte alignment. This means that (for example) a the string 'abcde' stored in a VARCHAR(50) column using the latin1 character set requires 12 bytes—in this case, 2 bytes times 5 characters is 10, rounded up to the next even multiple of 4 yields 12.

- For Disk Data columns, `VARCHAR` and `VARBINARY` are stored as fixed-width columns. This means that each of these types requires the same amount of storage as a `CHAR` of the same size.

Each row in an NDB Cluster `BLOB` or `TEXT` column is made up of two separate parts. One of these is of fixed size (256 bytes), and is actually stored in the original table. The other consists of any data in excess of 256 bytes, which stored in a hidden table. The rows in this second table are always 2000 bytes long. This means that record of *`size`* bytes in a `TEXT` or `BLOB` column requires

- 256 bytes, if `size <= 256`
- `256 + 2000 * ((size – 256) \ 2000) + 1)` bytes otherwise

Temporal data types. Storage of temporal types in the NDB API depends on whether MySQL's "old" types without fractional seconds or "new" types with fractional second support are used. Support for fractional seconds was introduced in MySQL 5.6 as well as the NDB Cluster versions based on it—that is, NDB 7.3 and NDB 7.4. These versions use the new temporal types by default, but can be made to use the old ones by starting `mysqld` with `--create-old-temporals=ON`. NDB 7.5 and later—that is, those NDB Cluster versions based on MySQL 5.7 and later—can read and write data using the old temporal types, but cannot create tables that use the old types. See Fractional Seconds in Time Values, for more about these changes in the MySQL server.

Because support for the old temporal types is expected be removed in a future release, you are encouraged to migrate any tables using the old temporal types to the new versions of these types. You can do this by executing a copying `ALTER TABLE` operation on any table using the old temporals, or by means of backing up and restoring any such tables.

You can see whether a given table uses the old or new temporal types by checking the output of the `ndb_desc` utility supplied with the NDB Cluster distribution. Consider a table created in a database named `test`, using the following statement, on a `mysqld` started without the `--create-old-temporals` option:

```
CREATE TABLE t1 (
    c1 DATETIME,
    c2 DATE,
    c3 TIME,
    c4 TIMESTAMP,
    c5 YEAR) ENGINE=NDB;
```

The relevant portion (the `Attributes` block) of the output of `ndb_desc` looks like this:

```
shell> ndb_desc -dtest t1
...
-- Attributes --
c1 Datetime2(0) NULL AT=FIXED ST=MEMORY
c2 Date NULL AT=FIXED ST=MEMORY
c3 Time2(0) NULL AT=FIXED ST=MEMORY
c4 Timestamp2(0) NOT NULL AT=FIXED ST=MEMORY DEFAULT 0
c5 Year NULL AT=FIXED ST=MEMORY
```

The names of the new MySQL temporal types are are suffixed with `2` (for example, `Datetime2`) to set them apart from the old versions of these types. Assume that we restart `mysqld` with `--create-old-temporals=ON` and then create a table `t2`, also in the `test` database, using this statement:

```
CREATE TABLE t2 (
    c1 DATETIME,
    c2 DATE,
    c3 TIME,
    c4 TIMESTAMP,
    c5 YEAR) ENGINE=NDB;
```

The output from executing `ndb_desc` on this table as shown includes the `Attributes` block shown here:

```
shell> ndb_desc -dtest t2
```

```
...
-- Attributes --
c1 Datetime NULL AT=FIXED ST=MEMORY
c2 Date NULL AT=FIXED ST=MEMORY
c3 Time NULL AT=FIXED ST=MEMORY
c4 Timestamp NOT NULL AT=FIXED ST=MEMORY DEFAULT 0
c5 Year NULL AT=FIXED ST=MEMORY
```

The affected MySQL types are `TIME`, `DATETIME`, and `TIMESTAMP`. The “new” versions of these types are reflected in the NDB API as `Time2`, `Datetime2`, and `Timestamp2`, respectively, each supporting fractional seconds with up to 6 digits of precision. The new variants use big-endian encoding of integer values which are then processed to determine the components of each temporal type.

For the fractional second part of each of these types, the precision affects the number of bytes needed, as shown in the following table:

Table 2.1 Precision of NDB API new temporal types

Precision	Bytes required	Range
0	0	—
1	1	0-9
2	1	0-99
3	2	0-999
4	2	0-9999
5	3	0-99999
6	3	0-999999

The fractional part for each of the new temporal types is stored in big-endian format—that is, with the highest order byte at the lowest address—using the necessary number of bytes.

The binary layouts of both the old and new versions of these types are described in the next few paragraphs.

`Time`: The “old” version of this type is stored as a 24-bit signed `int` value stored in little-endian format (lowest order byte in lowest order address). Byte 0 (bits 0-7) corresponds to hours, byte 2 (bits 8-15) to minutes, and byte 2 (bits 16-23) to seconds according to this formula:

```
value =   10000 * hour
        + 100 * minute
        + second
```

Bit 23 serves as the sign bit; if this bit is set, the time value is considered negative.

`Time2`: This is the “new” `TIME` type added in NDB 7.3 and 7.4 (MySQL 5.6), and is stored as a 3-byte big-endian encoded value plus 0 to 3 bytes for the fractional part. The integer part is encoded as shown in the following table:

Table 2.2 Time2 encoding

Bits	Meaning	Range
23	Sign bit	0-1
22	Interval	0-1
22-13	Hour	1-1023
12-7	Minute	0-63
6-0	Second	0-63

Any fractional bytes in addition to this are handled as described previously.

`Date`: The representation for the MySQL `DATE` type is unchanged across NDB versions, and uses a 3-byte unsigned integer stored in little-endian order. The encoding is as shown here:

Table 2.3 Date encoding

Bits	Meaning	Range
23-9	Year	0-32767
8-5	Month	0-15
4-0	Day	0-31

`Datetime`: The “old” MySQL `DATETIME` type is represented by a 64-bit unsigned value stored in host byte order, encoded using the following formula:

```
value   = second
        + minute   * 10^2
        + hour     * 10^4
        + day      * 10^6
        + month    * 10^8
        + year     * 10^10
```

`DateTime2`: The “new” `DATETIME` is encoded as a 5-byte big-endian with an optional fractional part of 0 to 3 bytes, the fractional portion being handled as described previously. The high 5 bytes are encoded as shown here:

Table 2.4 DateTime2 encoding

Bits	Meaning	Range
23	Sign bit	0-1
22	Interval	0-1
22-13	Hour	1-1023
12-7	Minute	0-63
6-0	Second	0-63

The `YearMonth` bits are encoded as `Year = YearMonth / 13` and `Month = YearMonth % 13`.

`Timestamp`: The “old” version of this type uses a 32-bit unsigned value representing seconds elapsed since the Unix epoch, stored in host byte order.

`Timestamp2`: This is the version of `TIMESTAMP` implemented in NDB 7.3 and 7.4 (MySQL 5.6), and uses 4 bytes with big-endian eoncoding for the integer potion (unsigned). The optional 3-byte fractional portion is encoded as exaplined earlier in this section.

Additional information. More information about and examples uding data types as expressed in the NDB API can be found in `ndb/src/common/util/NdbSqlUtil.cpp`. In addition, see Section 2.5.13, “Timestamp2 Example”, which provides an example of a simple NDB API application that makes use of the `Timestamp2` data type.

2.2 The NDB API Class Hierarachy

This section provides a hierarchical listing of all classes, interfaces, and structures exposed by the NDB API.

- `Ndb`
  - `Key_part_ptr`

  - PartitionSpec
- NdbBlob
- Ndb_cluster_connection
- NdbDictionary
  - AutoGrowSpecification
  - Dictionary
    - List
      - Element
  - Column
  - Object
    - Datafile
    - Event
    - ForeignKey
    - HashMap
    - Index
    - LogfileGroup
    - Table
    - Tablespace
    - Undofile
  - RecordSpecification
- NdbError
- NdbEventOperation
- NdbInterpretedCode
- NdbOperation
  - NdbIndexOperation
  - NdbScanOperation
    - NdbIndexScanOperation
      - IndexBound
    - ScanOptions
  - GetValueSpec
  - SetValueSpec
  - OperationOptions

- NdbRecAttr
- NdbRecord
- NdbScanFilter
- NdbTransaction

2.3 NDB API Classes, Interfaces, and Structures

This section provides a detailed listing of all classes, interfaces, and stuctures defined in the NDB API.

Each listing includes the following information:

- Description and purpose of the class, interface, or structure.
- Pointers, where applicable, to parent and child classes.
- Detailed listings of all public members, including descriptions of all method parameters and type values.

Class, interface, and structure descriptions are provided in alphabetic order. For a hierarchical listing, see Section 2.2, "The NDB API Class Hierarachy".

2.3.1 The AutoGrowSpecification Structure

This section describes the AutoGrowSpecification structure.

Parent class. NdbDictionary

Description. The AutoGrowSpecification is a data structure defined in the NdbDictionary class, and is used as a parameter to or return value of some of the methods of the Tablespace and LogfileGroup classes. See Section 2.3.38, "The Tablespace Class", and Section 2.3.13, "The LogfileGroup Class", for more information.

Methods. AutoGrowSpecification has the methods shown in the following table:

Table 2.5 NdbDictionary::AutoGrowSpecification data structure member names and descriptions

Name	Description
min_free	???
max_size	???
file_size	???
filename_pattern	???

2.3.2 The Column Class

This class represents a column in an NDB Cluster table.

Parent class. NdbDictionary

Child classes. *None*

Description. Each instance of Column is characterized by its type, which is determined by a number of type specifiers:

- Built-in type
- Array length or maximum length

- Precision and scale (*currently not in use*)
- Character set (applicable only to columns using string data types)
- Inline and part sizes (applicable only to `BLOB` columns)

These types in general correspond to MySQL data types and their variants. The data formats are same as in MySQL. The NDB API provides no support for constructing such formats; however, they are checked by the `NDB` kernel.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.6 Column class methods and descriptions

Method	Description
`Column()`	Class constructor; there is also a copy constructor
`~Column()`	Class destructor
`equal()`	Compares `Column` objects
`getArrayType()`	Gets the column's array type
`getCharset()`	Get the character set used by a string (text) column (not applicable to columns not storing character data)
`getColumnNo()`	Gets the column number
`getDefaultValue()`	Returns the column's default value
`getInlineSize()`	Gets the inline size of a `BLOB` column (not applicable to other column types)
`getLength()`	Gets the column's length
`getName()`	Gets the name of the column
`getNullable()`	Checks whether the column can be set to `NULL`
`getPartitionKey()`	Checks whether the column is part of the table's partitioning key
`getPartSize()`	Gets the part size of a `BLOB` column (not applicable to other column types)
`getPrecision()`	Gets the column's precision (used for decimal types only)
`getPrimaryKey()`	Check whether the column is part of the table's primary key
`getScale()`	Gets the column's scale (used for decimal types only)
`getSize()`	Gets the size of an element
`getSizeInBytesForRecord()`	Gets the space required for a column by `NdbRecord`, according to the column's type (added in NDB 7.3.10 and NDB 7.4.7)
`getStripeSize()`	Gets a BLOB column's stripe size (not applicable to other column types)
`getStorageType()`	Gets the storage type used by this column
`getType()`	Gets the column's type (`Type` value)
`setArrayType()`	Sets the column's `ArrayType`
`setCharset()`	Sets the character set used by a column containing character data (not applicable to nontextual columns)
`setDefaultValue()`	Sets the column's default value
`setInlineSize()`	Sets the inline size for a `BLOB` column (not applicable to non-`BLOB` columns)
`setLength()`	Sets the column's length

Method	Description
setName()	Sets the column's name
setNullable()	Toggles the column's nullability
setPartitionKey()	Determines whether the column is part of the table's partitioning key
setPartSize()	Sets the part size for a BLOB column (not applicable to non-BLOB columns)
setPrecision()	Sets the column's precision (used for decimal types only)
setPrimaryKey()	Determines whether the column is part of the primary key
setScale()	Sets the column's scale (used for decimal types only)
setStorageType()	Sets the storage type to be used by this column
setStripeSize()	Sets the stripe size for a BLOB column (not applicable to non-BLOB columns)
setType()	Sets the column's Type

For detailed descriptions, signatures, and examples of use for each of these methods, see Section 2.3.2.4, “Column Methods”.

Important

Columns created using this class cannot be seen by the MySQL Server. This means that they cannot be accessed by MySQL clients, and that they cannot be replicated. For these reasons, it is often preferable to avoid working with them.

Important

In the NDB API, column names are handled in case-sensitive fashion. (This differs from the MySQL C API.) To reduce the possibility for error, it is recommended that you name all columns consistently using uppercase or lowercase.

Types. These are the public types of the `Column` class:

Table 2.7 Column class types and descriptionse.

Type	Description
ArrayType	Specifies the column's internal storage format
StorageType	Determines whether the column is stored in memory or on disk
Type	The column's data type. NDB columns have the same data types as found in MySQL

2.3.2.1 Column::ArrayType

This type describes the `Column`'s internal attribute format.

Description. The attribute storage format can be either fixed or variable.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.8 Column object ArrayType data type values and descriptions

Name	Description
ArrayTypeFixed	stored as a fixed number of bytes
ArrayTypeShortVar	stored as a variable number of bytes; uses 1 byte overhead

Name	Description
ArrayTypeMediumVar	stored as a variable number of bytes; uses 2 bytes overhead

The fixed storage format is faster but also generally requires more space than the variable format. The default is ArrayTypeShortVar for Var* types and ArrayTypeFixed for others. The default is usually sufficient.

2.3.2.2 Column::StorageType

This type describes the storage type used by a Column object.

Description. The storage type used for a given column can be either in memory or on disk. Columns stored on disk mean that less RAM is required overall but such columns cannot be indexed, and are potentially much slower to access. The default is StorageTypeMemory.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.9 Column object StorageType data type values and descriptions

Name	Description
StorageTypeMemory	Store the column in memory
StorageTypeDisk	Store the column on disk

2.3.2.3 Column::Type

Type is used to describe the Column object's data type.

Description. Data types for Column objects are analogous to the data types used by MySQL. The types Tinyint, Tinyintunsigned, Smallint, Smallunsigned, Mediumint, Mediumunsigned, Int, Unsigned, Bigint, Bigunsigned, Float, and Double (that is, types Tinyint through Double in the order listed in the Enumeration Values table) can be used in arrays.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.10 Column object Type data type values and descriptions

Name	Description
Undefined	Undefined
Tinyint	1-byte signed integer
Tinyunsigned	1-byte unsigned integer
Smallint	2-byte signed integer
Smallunsigned	2-byte unsigned integer
Mediumint	3-byte signed integer
Mediumunsigned	3-byte unsigned integer
Int	4-byte signed integer
Unsigned	4-byte unsigned integer
Bigint	8-byte signed integer
Bigunsigned	8-byte signed integer
Float	4-byte float
Double	8-byte float
Olddecimal	Signed decimal as used prior to MySQL 5.0
Olddecimalunsigned	Unsigned decimal as used prior to MySQL 5.0

Name	Description
Decimal	Signed decimal as used by MySQL 5.0 and later
Decimalunsigned	Unsigned decimal as used by MySQL 5.0 and later
Char	A fixed-length array of 1-byte characters; maximum length is 255 characters
Varchar	A variable-length array of 1-byte characters; maximum length is 255 characters
Binary	A fixed-length array of 1-byte binary characters; maximum length is 255 characters
Varbinary	A variable-length array of 1-byte binary characters; maximum length is 255 characters
Datetime	An 8-byte date and time value, with a precision of 1 second (DEPRECATED)
Date	A 4-byte date value, with a precision of 1 day
Blob	A binary large object; see Section 2.3.18, “The NdbBlob Class”
Text	A text blob
Bit	A bit value; the length specifies the number of bits
Longvarchar	A 2-byte Varchar
Longvarbinary	A 2-byte Varbinary
Time	Time without date (DEPRECATED)
Year	1-byte year value in the range 1901-2155 (same as MySQL)
Timestamp	Unix time (DEPRECATED)
Time2	Time without date, with fractional seconds. Added in NDB 7.3.1.
Datetime2	An 8-byte date and time value, with fractional seconds. Added in NDB 7.3.1.
Timestamp2	Unix time, with fractional seconds. Added in NDB 7.3.1.

Beginning with NDB 7.3.1, the NDB API provides access to the time types with microseconds added in MySQL 5.6 (TIME, DATETIME, and TIMESTAMP) as Time2, Datetime2, and Timestamp2. (Time, Datetime, and Timestamp are deprecated as of the same version.) Use setPrecision() to set up to 6 fractional digits (default 0). Data formats are as in MySQL and must use the correct byte length. *Note*: Since NDB can compare any of these values as binary strings, it does not perform any checks on the actual data.

Caution

Do not confuse Column::Type with Object::Type.

2.3.2.4 Column Methods

This section documents the public methods of the Column class.

Note

The assignment (=) operator is overloaded for this class, so that it always performs a deep copy.

Warning

As with other database objects, Column object creation and attribute changes to existing columns done using the NDB API are not visible from MySQL. For

> example, if you change a column's data type using `Column::setType()`, MySQL will regard the type of column as being unchanged. The only exception to this rule with regard to columns is that you can change the name of an existing column using `Column::setName()`.
>
> Also remember that the NDB API handles column names in case-sensitive fashion.

Column Constructor

Description. You can create a new `Column` or copy an existing one using the class constructor.

> **Warning**
>
> A `Column` created using the NDB API is *not* visible to a MySQL server.

The NDB API handles column names in case-sensitive fashion. For example, if you create a column named “myColumn”, you will not be able to access it later using “Mycolumn” for the name. You can reduce the possibility for error, by naming all columns consistently using only uppercase or only lowercase.

Signature. You can create either a new instance of the `Column` class, or by copying an existing `Column` object. Both of these are shown here:

- Constructor for a new `Column`:

```
Column
    (
      const char* name = ""
    )
```

- Copy constructor:

```
Column
    (
      const Column& column
    )
```

Parameters. When creating a new instance of `Column`, the constructor takes a single argument, which is the name of the new column to be created. The copy constructor also takes one parameter—in this case, a reference to the `Column` instance to be copied.

Return value. A `Column` object.

Destructor. The `Column` class destructor takes no arguments and *None*.

Column::equal()

Description. This method is used to compare one `Column` with another to determine whether the two `Column` objects are the same.

Signature.

```
bool equal
    (
      const Column& column
    ) const
```

Parameters. `equal()` takes a single parameter, a reference to an instance of `Column`.

Return value. `true` if the columns being compared are equal, otherwise `false`.

Column::getArrayType()

Description. This method gets the column's array type.

Signature.

```
ArrayType getArrayType
    (
      void
    ) const
```

Parameters. *None*.

Return value. An `ArrayType`; see Section 2.3.2.1, "Column::ArrayType" for possible values.

Column::getCharset()

Description. This gets the character set used by a text column.

Note

This method is applicable only to columns whose `Type` value is `Char`, `Varchar`, or `Text`.

Important

The NDB API handles column names in case-sensitive fashion; "myColumn" and "Mycolumn" are not considered to refer to the same column. It is recommended that you minimize the possibility of errors from using the wrong lettercase for column names by naming all columns consistently using only uppercase or only lowercase.

Signature.

```
CHARSET_INFO* getCharset
    (
      void
    ) const
```

Parameters. *None*.

Return value. A pointer to a `CHARSET_INFO` structure specifying both character set and collation. This is the same as a MySQL `MY_CHARSET_INFO` data structure; for more information, see mysql_get_character_set_info(),in the MySQL Manual.

Column::getColumnNo()

Description. This method gets the sequence number of a column within its containing table or index. If the column is part of an index (such as when returned by `getColumn()`), it is mapped to its position within that index, and not within the table containing the index.

Signature.

```
int getColumnNo
    (
      void
    ) const
```

Parameters. *None*.

Return value. The column number as an integer.

Column::getDefaultValue()

Description. Gets a column's default value data.

To determine whether a table has any columns with default values, use `Table::hasDefaultValues()`.

Signature.

```
const void* getDefaultValue
    (
      unsigned int* len = 0
    ) const
```

Parameters. *`len`* holds either the length of the default value data, or 0 in the event that the column is nullable or has no default value.

Return value. The default value data.

Column::getInlineSize()

Description. This method retrieves the inline size of a `BLOB` column—that is, the number of initial bytes to store in the table's blob attribute. This part is normally in main memory and can be indexed.

> **Note**
>
> This method is applicable only to `BLOB` columns.

Signature.

```
int getInlineSize
    (
      void
    ) const
```

Parameters. *None*.

Return value. The `BLOB` column's inline size, as an integer.

Column::getLength()

Description. This method gets the length of a column. This is either the array length for the column or—for a variable length array—the maximum length.

Signature.

```
int getLength
    (
      void
    ) const
```

Parameters. *None*.

Return value. The (maximum) array length of the column, as an integer.

Column::getName()

Description. This method returns the name of the column for which it is called.

> **Important**
>
> The NDB API handles column names in case-sensitive fashion. For example, if you retrieve the name “myColumn” for a given column, attempting to access this column using “Mycolumn” for the name fails with an error such as `Column is NULL` or `Table definition has undefined column`. You can reduce the possibility for error, by naming all columns consistently using only uppercase or only lowercase.

Signature.

```
const char* getName
    (
      void
    ) const
```

Parameters. *None*.

Return value. The name of the column.

Column::getNullable()

Description. This method is used to determine whether the column can be set to `NULL`.

Signature.

```
bool getNullable
    (
      void
    ) const
```

Parameters. *None*.

Return value. A Boolean value: `true` if the column can be set to `NULL`, otherwise `false`.

Column::getPartitionKey()

Description. This method is used to check whether the column is part of the table's partitioning key.

> **Note**
>
> A *partitioning key* is a set of attributes used to distribute the tuples onto the data nodes. This key a hashing function specific to the `NDB` storage engine.
>
> An example where this would be useful is an inventory tracking application involving multiple warehouses and regions, where it might be good to use the warehouse ID and district id as the partition key. This would place all data for a specific district and warehouse in the same storage node. Locally to each fragment the full primary key will still be used with the hashing algorithm in such a case.
>
> For more information about partitioning, partitioning schemes, and partitioning keys in MySQL, see Partitioning, in the MySQL Manual.

> **Important**
>
> The only type of user-defined partitioning that is supported for use with the `NDB` storage engine is key partitioning, including linear key partitioning.

Signature.

```
bool getPartitionKey
    (
      void
    ) const
```

Parameters. *None*.

Return value. `true` if the column is part of the partitioning key for the table, otherwise `false`.

Column::getPartSize()

Description. This method is used to get the part size of a `BLOB` column—that is, the number of bytes that are stored in each tuple of the blob table.

Note

This method is applicable to `BLOB` columns only.

Signature.

```
int getPartSize
    (
      void
    ) const
```

Parameters. *None*.

Return value. The column's part size, as an integer. In the case of a `Tinyblob` column, this value is `0` (that is, only inline bytes are stored).

Column::getPrecision()

Description. This method gets the precision of a column.

Note

This method is applicable to decimal columns only.

Signature.

```
int getPrecision
    (
      void
    ) const
```

Parameters. *None*.

Return value. The column's precision, as an integer. The precision is defined as the number of significant digits; for more information, see the discussion of the `DECIMAL` data type in Numeric Data Types, in the MySQL Manual.

Column::getPrimaryKey()

Description. This method is used to determine whether the column is part of the table's primary key.

Signature.

```
bool getPrimaryKey
    (
      void
    ) const
```

Parameters. *None*.

Return value. A Boolean value: `true` if the column is part of the primary key of the table to which this column belongs, otherwise `false`.

Column::getScale()

Description. This method gets the scale used for a decimal column value.

Note

This method is applicable to decimal columns only.

Signature.

```
int getScale
    (
      void
    ) const
```

Parameters. *None*.

Return value. The decimal column's scale, as an integer. The scale of a decimal column represents the number of digits that can be stored following the decimal point. It is possible for this value to be `0`. For more information, see the discussion of the `DECIMAL` data type in Numeric Data Types, in the MySQL Manual.

Column::getSize()

Description. This function is used to obtain the size of a column.

Signature.

```
int getSize
    (
      void
    ) const
```

Parameters. *None*.

Return value. The column's size in bytes (an integer value).

Column::getSizeInBytesForRecord()

Description. Gets the space required for a given column by an `NdbRecord`, depending on the column's type, as follows:

- For a BLOB column, this value is the same as `sizeof(NdbRecord*)`, which is 4 or 8 bytes (the size of a pointer; platform-dependent).
- For columns of all other types, it is the same as the value returned by `getSize()`.

This method was added in NDB 7.3.10 and NDB 7.4.7.

Signature.

```
int getSizeInBytesForRecord
    (
      void
    ) const
```

Parameters. *None*.

Return value. An integer (see Description).

Column::getStorageType()

Description. This method obtains a column's storage type.

Signature.

```
StorageType getStorageType
    (
      void
    ) const
```

Parameters. *None*.

Return value. A `StorageType` value; for more information about this type, see Section 2.3.2.2, “Column::StorageType”.

Column::getStripeSize()

Description. This method gets the stripe size of a `BLOB` column—that is, the number of consecutive parts to store in each node group.

Signature.

```
int getStripeSize
    (
      void
    ) const
```

Parameters. *None*.

Return value. The column's stripe size, as an integer.

Column::getType()

Description. This method gets the column's data type.

Signature.

```
Type getType
    (
      void
    ) const
```

Parameters. *None*.

Return value. The `Type` (data type) of the column. For a list of possible values, see Section 2.3.2.3, "Column::Type".

Column::setArrayType()

Description. Sets the array type for the column.

Signature.

```
void setArrayType
    (
      ArrayType type
    )
```

Parameters. A `Column::ArrayType` value. See Section 2.3.2.1, "Column::ArrayType", for more information.

Return value. *None*.

Column::setCharset()

Description. This method can be used to set the character set and collation of a `Char`, `Varchar`, or `Text` column.

> **Important**
>
> This method is applicable to `Char`, `Varchar`, and `Text` columns only.
>
> Changes made to columns using this method are not visible to MySQL.

Signature.

```
void setCharset
    (
      CHARSET_INFO* cs
    )
```

Parameters. This method takes one parameter. *`cs`* is a pointer to a `CHARSET_INFO` structure. For additional information, see Column::getCharset().

Return value. *None*.

Column::setDefaultValue()

Description. This method sets a column value to its default, if it has one; otherwise it sets the column to `NULL`.

To determine whether a table has any columns with default values, use `Table::hasDefaultValues()`.

Signature.

```
int setDefaultValue
    (
      const void* buf,
      unsigned int len
    )
```

Parameters. This method takes 2 arguments: a value pointer *`buf`*; and the length *`len`* of the data, as the number of significant bytes. For fixed size types, this is the type size. For variable length types, the leading 1 or 2 bytes pointed to by *`buffer`* also contain size information as normal for the type.

Return value. 0 on success, 1 on failure..

Column::setInlineSize

Description. This method gets the inline size of a `BLOB` column—that is, the number of initial bytes to store in the table's blob attribute. This part is normally kept in main memory, and can be indexed and interpreted.

> **Important**
>
> This method is applicable to `BLOB` columns only.
>
> Changes made to columns using this method are not visible to MySQL.

Signature.

```
void setInlineSize
    (
      int size
    )
```

Parameters. The integer *`size`* is the new inline size for the `BLOB` column.

Return value. *None*.

Column::setLength()

Description. This method sets the length of a column. For a variable-length array, this is the maximum length; otherwise it is the array length.

> **Important**
>
> Changes made to columns using this method are not visible to MySQL.

Signature.

```
void setLength
    (
      int length
```

```
    )
```

Parameters. This method takes a single argument—the integer value *`length`* is the new length for the column.

Return value. *None*.

Column::setName()

Description. This method is used to set the name of a column.

> **Important**
>
> `setName()` is the only `Column` method whose result is visible from a MySQL Server. MySQL cannot see any other changes made to existing columns using the NDB API.

Signature.

```
void setName
    (
      const char* name
    )
```

Parameters. This method takes a single argument—the new name for the column.

Return value. This method *None*.

Column::setNullable()

Description. This method toggles the nullability of a column.

> **Important**
>
> Changes made to columns using this method are not visible to MySQL.

Signature.

```
void setNullable
    (
      bool nullable
    )
```

Parameters. A Boolean value. Using `true` makes it possible to insert `NULL`s into the column; if *`nullable`* is `false`, then this method performs the equivalent of changing the column to `NOT NULL` in MySQL.

Return value. *None*.

Column::setPartitionKey()

Description. This method makes it possible to add a column to the partitioning key of the table to which it belongs, or to remove the column from the table's partitioning key.

> **Important**
>
> Changes made to columns using this method are not visible to MySQL.
>
> For additional information, see Column::getPartitionKey().

Signature.

```
void setPartitionKey
    (
```

```
    bool enable
  )
```

Parameters. The single parameter *`enable`* is a Boolean value. Passing `true` to this method makes the column part of the table's partitioning key; if *`enable`* is `false`, then the column is removed from the partitioning key.

Return value. *None*.

Column::setPartSize()

Description. This method sets the part size of a `BLOB` column—that is, the number of bytes to store in each tuple of the `BLOB` table.

> **Important**
>
> This method is applicable to `BLOB` columns only.
>
> Changes made to columns using this method are not visible to MySQL.

Signature.

```
void setPartSize
  (
    int size
  )
```

Parameters. The integer *`size`* is the number of bytes to store in the `BLOB` table. Using zero for this value means only inline bytes can be stored, in effect making the column's type `TINYBLOB`.

Return value. *None*.

Column::setPrecision()

Description. This method can be used to set the precision of a decimal column.

> **Important**
>
> This method is applicable to decimal columns only.
>
> Changes made to columns using this method are not visible to MySQL.

Signature.

```
void setPrecision
  (
    int precision
  )
```

Parameters. This method takes a single parameter—precision is an integer, the value of the column's new precision. For additional information about decimal precision and scale, see Column::getPrecision(), and Column::getScale().

Return value. *None*.

Column::setPrimaryKey()

Description. This method is used to make a column part of the table's primary key, or to remove it from the primary key.

> **Important**
>
> Changes made to columns using this method are not visible to MySQL.

Signature.

```
void setPrimaryKey
    (
      bool primary
    )
```

Parameters. This method takes a single Boolean value. If it is `true`, then the column becomes part of the table's primary key; if `false`, then the column is removed from the primary key.

Return value. *None*.

Column::setScale()

Description. This method can be used to set the scale of a decimal column.

Important

This method is applicable to decimal columns only.

Changes made to columns using this method are not visible to MySQL.

Signature.

```
void setScale
    (
      int scale
    )
```

Parameters. This method takes a single parameter—the integer *`scale`* is the new scale for the decimal column. For additional information about decimal precision and scale, see Column::getPrecision(), and Column::getScale().

Return value. *None*.

Column::setStripeSize()

Description. This method sets the stripe size of a `BLOB` column—that is, the number of consecutive parts to store in each node group.

Important

This method is applicable to `BLOB` columns only.

Changes made to columns using this method are not visible to MySQL.

Signature.

```
void setStripeSize
    (
      int size
    )
```

Parameters. This method takes a single argument. The integer *`size`* is the new stripe size for the column.

Return value. *None*.

Column::setStorageType()

Description. Sets the storage type for the column.

Signature.

```
void setStorageType
```

```
    (
      StorageType type
    )
```

Parameters. A `Column::StorageType` value. See Section 2.3.2.2, “Column::StorageType”, for more information.

Return value. *None*.

Column::setType()

Description. This method sets the `Type` (data type) of a column.

> **Important**
>
> `setType()` resets *all* column attributes to their (type dependent) default values; it should be the first method that you call when changing the attributes of a given column.
>
> Changes made to columns using this method are not visible to MySQL.

Signature.

```
void setType
    (
      Type type
    )
```

Parameters. This method takes a single parameter—the new `Column::Type` for the column. The default is `Unsigned`. For a listing of all permitted values, see Section 2.3.2.3, “Column::Type”.

Return value. *None*.

2.3.3 The Datafile Class

This section covers the `Datafile` class.

Parent class. `Object`

Child classes. *None*

Description. The `Datafile` class models a Cluster Disk Data datafile, which is used to store Disk Data table data.

> **Note**
>
> Currently, only unindexed column data can be stored on disk. Indexes and indexed columns are stored in memory.
>
> NDB Cluster prior to MySQL 5.1 did not support Disk Data storage and so did not support datafiles; thus the `Datafile` class is unavailable for NDB API applications written against these older releases.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.11 Datafile class methods and descriptions

Name	Description
`Datafile()`	Class constructor
`~Datafile()`	Destructor
`getFileNo()`	Removed in NDB 7.5.0 (Bug #47960, Bug #11756088)

Name	Description
getFree()	Gets the amount of free space in the datafile
getNode()	Removed in NDB 7.5.0 (Bug #47960, Bug #11756088)
getObjectId()	Gets the datafile's object ID
getObjectStatus()	Gets the datafile's object status
getObjectVersion()	Gets the datafile's object version
getPath()	Gets the file system path to the datafile
getSize()	Gets the size of the datafile
getTablespace()	Gets the name of the tablespace to which the datafile belongs
getTablespaceId()	Gets the ID of the tablespace to which the datafile belongs
setNode()	Removed in NDB 7.5.0 (Bug #47960, Bug #11756088)
setPath()	Sets the name and location of the datafile on the file system
setSize()	Sets the datafile's size
setTablespace()	Sets the tablespace to which the datafile belongs

Types. The `Datafile` class defines no public types.

2.3.3.1 Datafile Class Constructor

Description. This method creates a new instance of `Datafile`, or a copy of an existing one.

Signature. To create a new instance:

```
Datafile
    (
      void
    )
```

To create a copy of an existing `Datafile` instance:

```
Datafile
    (
      const Datafile& datafile
    )
```

Parameters. New instance: *None*. Copy constructor: a reference to the `Datafile` instance to be copied.

Return value. A `Datafile` object.

2.3.3.2 Datafile::getFileNo()

Description. This method did not work as intended, and was removed in NDB 7.5.0 (Bug #47960, Bug #11756088).

Signature.

```
Uint32 getFileNo
    (
      void
    ) const
```

Parameters. *None*.

Return value. The file number, as an unsigned 32-bit integer.

2.3.3.3 Datafile::getFree()

Description. This method gets the free space available in the datafile.

Signature.

```
Uint64 getFree
    (
      void
    ) const
```

Parameters. *None*.

Return value. The number of bytes free in the datafile, as an unsigned 64-bit integer.

2.3.3.4 Datafile::getNode()

Description. This method did not work as intended, and was removed in NDB 7.5.0 (Bug #47960, Bug #11756088).

Signature.

```
Uint32 getNode
    (
      void
    ) const
```

Parameters. *None*.

Return value. The node ID as an unsigned 32-bit integer.

2.3.3.5 Datafile::getObjectId()

Description. This method is used to obtain the object ID of the datafile.

Signature.

```
virtual int getObjectId
    (
      void
    ) const
```

Parameters. *None*.

Return value. The datafile's object ID, as an integer.

2.3.3.6 Datafile::getObjectStatus()

Description. This method is used to obtain the datafile's object status.

Signature.

```
virtual Object::Status getObjectStatus
    (
      void
    ) const
```

Parameters. *None*.

Return value. The datafile's `Status`. See Section 2.3.31.4, “Object::Status”.

2.3.3.7 Datafile::getObjectVersion()

Description. This method retrieves the datafile's object version (see NDB Schema Object Versions).

Signature.

```
virtual int getObjectVersion
    (
      void
    ) const
```

Parameters. *None*.

Return value. The datafile's object version, as an integer.

2.3.3.8 Datafile::getPath()

Description. This method returns the file system path to the datafile.

Signature.

```
const char* getPath
    (
      void
    ) const
```

Parameters. *None*.

Return value. The path to the datafile on the data node's file system, a string (character pointer).

2.3.3.9 Datafile::getSize()

Description. This method gets the size of the datafile in bytes.

Signature.

```
Uint64 getSize
    (
      void
    ) const
```

Parameters. *None*.

Return value. The size of the data file, in bytes, as an unsigned 64-bit integer.

2.3.3.10 Datafile::getTablespace()

Description. This method can be used to obtain the name of the tablespace to which the datafile belongs.

> **Note**
>
> You can also access the associated tablespace's ID directly. See Section 2.3.3.11, "Datafile::getTablespaceId()".

Signature.

```
const char* getTablespace
    (
      void
    ) const
```

Parameters. *None*.

Return value. The name of the associated tablespace (as a character pointer).

2.3.3.11 Datafile::getTablespaceId()

Description. This method gets the ID of the tablespace to which the datafile belongs.

> **Note**
>
> You can also access the name of the associated tablespace directly. See Section 2.3.3.10, "Datafile::getTablespace()".

Signature.

```
Uint32 getTablespaceId
    (
      void
    ) const
```

Parameters. *None*.

Return value. This method returns the tablespace ID as an unsigned 32-bit integer.

2.3.3.12 Datafile::setNode()

Description. This method did not work as intended, and was removed in NDB 7.5.0 (Bug #47960, Bug #11756088).

Signature.

```
void setNode
    (
      Uint32 nodeId
    )
```

Parameters. The *`nodeId`* of the node on which the datafile is to be located (an unsigned 32-bit integer value).

Return value. *None*.

2.3.3.13 Datafile::setPath()

Description. This method sets the path to the datafile on the data node's file system.

Signature.

```
const char* setPath
    (
      void
    ) const
```

Parameters. The path to the file, a string (as a character pointer).

Return value. *None*.

2.3.3.14 Datafile::setSize()

Description. This method sets the size of the datafile.

Signature.

```
void setSize
    (
      Uint64 size
    )
```

Parameters. This method takes a single parameter—the desired *`size`* in bytes for the datafile, as an unsigned 64-bit integer.

Return value. *None*.

2.3.3.15 Datafile::setTablespace()

Description. This method is used to associate the datafile with a tablespace.

Signatures. `setTablespace()` can be invoked in either of two ways, listed here:

- Using the name of the tablespace, as shown here:

```
void setTablespace
    (
      const char* name
    )
```

- Using a reference to a `Tablespace` object.

```
void setTablespace
    (
      const class Tablespace& tablespace
    )
```

Parameters. This method takes a single parameter, which can be either one of the following:

- The *`name`* of the tablespace (as a character pointer).
- A reference *`tablespace`* to the corresponding `Tablespace` object.

Return value. *None*.

2.3.4 The Dictionary Class

This section describes the `Dictionary` class.

Parent class. `NdbDictionary`

Child classes. `List`

Description. This is used for defining and retrieving data object metadata. It also includes methods for creating and dropping database objects.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.12 Dictionary class methods and descriptions

Name	Description
`Dictionary()`	Class constructor method
`~Dictionary()`	Destructor method
`beginSchemaTrans()`	Begins a schema transaction
`createDatafile()`	Creates a datafile
`createEvent()`	Creates an event
`createForeignKey()`	Creates a foreign key
`createHashMap()`	Creates a has map
`createIndex()`	Creates an index
`createLogfileGroup()`	Creates a logfile group
`createRecord()`	Creates an `Ndbrecord` object
`createTable()`	Creates a table

Name	Description
`createTablespace()`	Creates a tablespace
`createUndofile()`	Creates an undofile
`dropDatafile()`	Drops a datafile
`dropEvent()`	Drops an event
`dropForeignKey()`	Drops a foreign key
`dropIndex()`	Drops an index
`dropLogfileGroup()`	Drops a logfile group
`dropTable()`	Drops a table
`dropTablespace()`	Drops a tablespace
`dropUndofile()`	Drops an undofile
`endSchemaTrans()`	Ends (commits and closes) a schema transaction
`getDatafile()`	Gets the datafile having the given name
`getDefaultHashMap()`	Gets a table's default hash map
`getEvent()`	Gets the event having the given name
`getForeignKey()`	Gets the foreign key having the given name or reference
`getHashMap()`	Gets the hash map given its name or associated table
`getIndex()`	Gets the index having the given name
`getLogfileGroup()`	Gets the logfile group having the given name
`getNdbError()`	Retrieves the latest error
`getTable()`	Gets the table having the given name
`getTablespace()`	Gets the tablespace having the given name
`getUndofile()`	Gets the undofile having the given name
`hasSchemaTrans()`	Tells whether a schema transaction currently exists
`initDefaultHashMap()`	Initializes a atble' default hash map
`invalidateTable()`	Invalidates a table object
`listObjects()`	Fetches a list of the objects in the dictionary
`listIndexes()`	Fetches a list of the indexes defined on a given table
`listEvents()`	Fetches a list of the events defined in the dictionary
`prepareHashMap()`	Creates or retrieves a hash map that can be updated
`removeCachedTable()`	Removes a table from the local cache
`removeCachedIndex()`	Removes an index from the local cache

Important

Database objects such as tables and indexes created using the `Dictionary::create*()` methods cannot be seen by the MySQL Server. This means that they cannot be accessed by MySQL clients, and that they cannot be replicated. For these reasons, it is often preferable to avoid working with them.

Note

The `Dictionary` class does not have any methods for working directly with columns. You must use `Column` class methods for this purpose—see Section 2.3.2, “The Column Class”, for details.

Types. See Section 2.3.14, “The List Class”, and Section 2.3.5, “The Element Structure”.

2.3.4.1 Dictionary Class Constructor

Description. This method creates a new instance of the `Dictionary` class.

> **Note**
>
> Both the constructor and destructor for this class are protected methods, rather than public.

Signature.

```
protected Dictionary
    (
      Ndb& ndb
    )
```

Parameters. An `Ndb` object.

Return value. A `Dictionary` object.

Destructor. The destructor takes no parameters and returns nothing.

```
protected ~Dictionary
    (
      void
    )
```

2.3.4.2 Dictionary::beginSchemaTrans()

Description. Starts a schema transaction. An error occurs if a transaction is already active, or if the kernel metadata is locked. You can determine whether a schema transaction already exists using the `hasSchemaTrans()` method.

A *metadata operation* occurs whenever data objects are created, altered, or dropped; such an operation can create additional suboperations in the NDB kernel.

The `Ndb` object and its associated `Dictionary` support one schema transaction at a time. By default, each metadata operation is executed separately; that is, for each operation, a schema transaction is started implicitly, the operation (including any suboperations) is executed, and the transaction is closed.

It is also possible to begin and end a schema transaction explicitly, and execute a set of user-defined operations atomically within its boundaries. In this case, all operations within the schema transaction either succeed, or are aborted and rolled back, as a unit. This is done by following the steps listed here:

1. To begin the schema transaction, call `beginSchemaTrans()`.

2. Execute the desired operations (such as `createTable()`).

3. End the schema transaction by calling `endSchemaTrans`.

Each operation is sent to the NDB kernel, which parses and saves it. A parse failure results in a rollback to the previous user operation before returning, at which point the user can either continue with or abort the entire transaction.

After all operations have been submitted, `endSchemaTrans()` processes and commits them. In the event of an error, the transaction is immediately aborted.

If the user exits before calling `endSchemaTrans()`, the NDB kernel aborts the transaction. If the user exits before the call to `endSchemaTrans()` returns, the kernel continues with the request, and its completion status is reported in the cluster log.

Signature.

```
int beginSchemaTrans
    (
      void
    )
```

Parameters. *None*.

Return value. Returns 0 on success, -1 on error.

2.3.4.3 Dictionary::createDatafile()

Description. This method creates a new datafile, given a `Datafile` object.

Signature.

```
int createDatafile
    (
      const Datafile& dFile
    )
```

Parameters. A single argument—a reference to an instance of `Datafile`—is required.

Return value. `0` on success, `-1` on failure.

2.3.4.4 Dictionary::createEvent()

Description. Creates an event, given a reference to an `Event` object.

You should keep in mind that the NDB API does not track allocated event objects, which means that the user must delete the `Event` that was obtained using `createEvent()`, after this object is no longer required.

Signature.

```
int createEvent
    (
      const Event& event
    )
```

Parameters. A reference *`event`* to an `Event` object.

Return value. `0` on success, `-1` on failure.

2.3.4.5 Dictionary::createForeignKey()

Description. Creates a `ForeignKey` object, given a reference to this object and an `Object` ID.

Signature.

```
int createForeignKey
    (
      const ForeignKey&,
      ObjectId* = 0,
      int flags = 0
    )
```

Parameters. A reference to the `ForeignKey` object, and an `Object` ID. An optional value *`flags`*, if used, allows the creation of the foreign key without performing any foreign key checks. If set, its value must be `CreateFK_NoVerify` (1).

Return value. `0` on success.

2.3.4.6 Dictionary::createHashMap()

Description. Creates a HashMap.

Signature.

```
int createHashMap
    (
      const HashMap& hashmap,
      ObjectId* id = 0
    )
```

Parameters. A reference to the hash map, and, optionally, an ID to be assigned to it.

Return value. Returns 0 on success; on failure, returns -1 and sets an error.

2.3.4.7 Dictionary::createIndex()

Description. This method creates an index given an instance of Index and possibly an optional instance of Table.

Signature. This method can be invoked with or without a reference to a table object:

```
int createIndex
    (
      const Index& index
    )
```

```
int createIndex
    (
      const Index& index,
      const Table& table
    )
```

Parameters. *Required*: A reference to an Index object. *Optional*: A reference to a Table object.

Return value. 0 on success, -1 on failure.

2.3.4.8 Dictionary::createLogfileGroup()

Description. This method creates a new logfile group, given an instance of LogfileGroup.

Signature.

```
int createLogfileGroup
    (
      const LogfileGroup& lGroup
    )
```

Parameters. A single argument, a reference to a LogfileGroup object, is required.

Return value. 0 on success, -1 on failure.

2.3.4.9 Dictionary::createRecord()

Description. This method is used to create an NdbRecord object for use in table or index scanning operations.

Signature. The signature of this method depends on whether the resulting NdbRecord is to be used in table or index operations:

To create an NdbRecord for use in table operations, use the following:

```
NdbRecord* createRecord
    (
      const Table* table,
```

```
        const RecordSpecification* recSpec,
        Uint32 length,
        Uint32 elSize
    )
```

To create an NdbRecord for use in index operations, you can use either of the following:

```
NdbRecord* createRecord
    (
        const Index* index,
        const Table* table,
        const RecordSpecification* recSpec,
        Uint32 length,
        Uint32 elSize
    )
```

or

```
NdbRecord* createRecord
    (
        const Index* index,
        const RecordSpecification* recSpec,
        Uint32 length,
        Uint32 elSize
    )
```

Parameters. Dictionary::createRecord() takes the following parameters:

- If this NdbRecord is to be used with an index, a pointer to the corresponding Index object. If the NdbRecord is to be used with a table, this parameter is omitted. (See Section 2.3.11, “The Index Class”.)
- A pointer to a Table object representing the table to be scanned. If the Ndbrecord produced is to be used with an index, then this optionally specifies the table containing that index. (See Section 2.3.37, “The Table Class”.)
- A RecordSpecification used to describe a column. (See Section 2.3.34, “The RecordSpecification Structure”.
- The *length* of the record.
- The size of the elements making up this record.

Return value. An NdbRecord for use in operations involving the given table or index.

Example. See Section 2.3.27, “The NdbRecord Interface”.

2.3.4.10 Dictionary::createTable()

Description. Creates a table given an instance of Table.

Note

Tables created using this method cannot be seen by the MySQL Server, cannot be updated by MySQL clients, and cannot be replicated.

Signature.

```
int createTable
    (
        const Table& table
    )
```

Parameters. An instance of Table. See Section 2.3.37, “The Table Class”, for more information.

Return value. 0 on success, -1 on failure.

2.3.4.11 Dictionary::createTablespace()

Description. This method creates a new tablespace, given a `Tablespace` object.

Signature.

```
int createTablespace
    (
      const Tablespace& tSpace
    )
```

Parameters. This method requires a single argument—a reference to an instance of `Tablespace`.

Return value. `0` on success, `-1` on failure.

2.3.4.12 Dictionary::createUndofile()

Description. This method creates a new undofile, given an `Undofile` object.

Signature.

```
int createUndofile
    (
      const Undofile& uFile
    )
```

Parameters. This method requires one argument: a reference to an instance of `Undofile`.

Return value. `0` on success, `-1` on failure.

2.3.4.13 Dictionary::dropDatafile()

Description. This method drops a data file, given a `Datafile` object.

Signature.

```
int dropDatafile
    (
      const Datafile& dFile
    )
```

Parameters. A single argument—a reference to an instance of `Datafile`—is required.

Return value. `0` on success, `-1` on failure.

2.3.4.14 Dictionary::dropEvent()

Description. This method drops an event, given a reference to an `Event` object.

Signature.

```
int dropEvent
    (
      const char* name,
      int         force = 0
    )
```

Parameters. This method takes two parameters:

- The *`name`* of the event to be dropped, as a string.
- By default, `dropEvent()` fails if the event specified does not exist. You can override this behavior by passing any nonzero value for the (optional) *`force`* argument; in this case no check is made as to whether there actually is such an event, and an error is returned only if the event exists but it was for whatever reason not possible to drop it.

Return value. `0` on success, `-1` on failure.

2.3.4.15 Dictionary::dropForeignKey()

Description. This method drops a foreign key, given a reference to an `ForeignKey` object to be dropped.

Signature.

```
int dropForeignKey
    (
      const ForeignKey&
    )
```

Parameters. A reference to the `ForeignKey` to be dropped.

Return value. `0` on success.

2.3.4.16 Dictionary::dropIndex()

Description. This method drops an index given an instance of `Index`, and possibly an optional instance of `Table`.

Signature.

```
int dropIndex
    (
      const Index& index
    )
```

```
int dropIndex
    (
      const Index& index,
      const Table& table
    )
```

Parameters. This method takes two parameters, one of which is optional:

- **Required.** A reference to an `Index` object.
- **Optional.** A reference to a `Table` object.

Return value. `0` on success, `-1` on failure.

2.3.4.17 Dictionary::dropLogfileGroup()

Description. Given an instance of `LogfileGroup`, this method drops the corresponding log file group.

Signature.

```
int dropLogfileGroup
    (
      const LogfileGroup& lGroup
    )
```

Parameters. A single argument, a reference to a `LogfileGroup` object, is required.

Return value. `0` on success, `-1` on failure.

2.3.4.18 Dictionary::dropTable()

Description. Drops a table given an instance of `Table`.

Signature.

```
int dropTable
    (
      const Table& table
    )
```

In NDB 7.3.5 and later, this method drops all foreign key constraints on the `table` that is being dropped, whether the dropped table acts as a parent table, child table, or both. (Bug #18069680)

Prior to NDB 8.0.17, an `NDB` table dropped using this method persisted in the MySQL data dictionary but could not be dropped using `DROP TABLE` in the `mysql` client. In NDB 8.0.17 and later, such “orphan” tables can be dropped using `DROP TABLE`. (Bug #29125206, Bug #93672)

Parameters. An instance of `Table`. See Section 2.3.37, “The Table Class”, for more information.

Return value. `0` on success, `-1` on failure.

2.3.4.19 Dictionary::dropTablespace()

Description. This method drops a tablespace, given a `Tablespace` object.

Signature.

```
int dropTablespace
    (
      const Tablespace& tSpace
    )
```

Parameters. This method requires a single argument—a reference to an instance of `Tablespace`.

Return value. `0` on success, `-1` on failure.

2.3.4.20 Dictionary::dropUndofile()

Description. This method drops an undo file, given an `Undofile` object.

Signature.

```
int dropUndofile
    (
      const Undofile& uFile
    )
```

Parameters. This method requires one argument: a reference to an instance of `Undofile`.

Return value. `0` on success, `-1` on failure.

2.3.4.21 Dictionary::endSchemaTrans()

Description. Ends a schema transaction begun with `beginSchemaTrans()`; causes operations to be processed and either committed, or aborted and rolled back. This method combines transaction execution and closing; separate methods for these tasks are not required (or implemented). This method may be called successfully even if no schema transaction is currently active.

Note

As with many other NDB API methods, it is entirely possible for `endSchemaTrans()` to overwrite any current error code. For this reason, you should first check for and save any error code that may have resulted from a previous, failed operation.

Signature.

```
int endSchemaTrans
    (
```

```
    Uint32 flags = 0
  )
```

Parameters. The flags determines how the completed transaction is handled. The default is 0, which causes the transaction to be committed.

Dictionary::SchemaTransFlag. You can also use with `endSchemaTrans()` either of the `SchemaTransFlag` values shown here:

- `SchemaTransAbort` (= 1): Causes the transaction to be aborted
- `SchemaTransBackground` (= 2): Causes the transaction to execute in the background; the result is written to the cluster log, while the application continues without waiting for a response.

Return value. Returns 0 on success; in the event of an error, returns -1 and sets an `NdbError` error code.

2.3.4.22 Dictionary::getDatafile()

Description. This method is used to retrieve a `Datafile` object, given the node ID of the data node where a datafile is located and the path to the datafile on that node's file system.

Signature.

```
Datafile getDatafile
  (
    Uint32      nodeId,
    const char* path
  )
```

Parameters. This method must be invoked using two arguments, as shown here:

- The 32-bit unsigned integer *`nodeId`* of the data node where the datafile is located
- The *`path`* to the datafile on the node's file system (string as character pointer)

Return value. A `Datafile` object—see Section 2.3.3, “The Datafile Class”, for details.

2.3.4.23 Dictionary::getDefaultHashMap()

Description. Get a table's default hash map.

Signature.

```
int getDefaultHashMap
  (
    HashMap& dst,
    Uint32 fragments
  )
```

or

```
int getDefaultHashMap
  (
    HashMap& dst,
    Uint32 buckets,
    Uint32 fragments
  )
```

Return value. Returns 0 on success; on failure, returns -1 and sets an error.

2.3.4.24 Dictionary::getEvent()

Description. This method is used to obtain a new `Event` object representing an event, given the event's name.

`getEvent()` allocates memory each time it is successfully called. You should keep in mind that successive invocations of this method using the same event name return multiple, distinct objects.

The NDB API does not track allocated event objects, which means that the user must delete each `Event` created using `getEvent()`, after the object is no longer required.

Signature.

```
const Event* getEvent
    (
      const char* eventName
    )
```

Parameters. The *`eventName`*, a string (character pointer).

Return value. A pointer to an `Event` object. See Section 2.3.6, “The Event Class”, for more information.

2.3.4.25 Dictionary::getForeignKey()

Description. This method is used to obtain a new `ForeignKey` object representing an event, given a reference to the foreign key and its name.

Signature.

```
int getForeignKey
    (
      ForeignKey& dst,
      const char* name
    )
```

Parameters. A reference to the foreign key and its *`name`*, a string (character pointer).

Return value. A pointer to a `ForeignKey` object.

2.3.4.26 Dictionary::getHashMap()

Description. Gets a hash map by name or by table.

Signature.

```
int getHashMap
    (
      HashMap& dst,
      const char* name
    )
```

or

```
int getHashMap
    (
      HashMap& dst,
      const Table* table
    )
```

Parameters. A reference to the hash map and either a name or a `Table`.

Return value. Returns 0 on success; on failure, returns -1 and sets an error.

2.3.4.27 Dictionary::getIndex()

Description. This method retrieves a pointer to an index, given the name of the index and the name of the table to which the table belongs.

Signature.

```
const Index* getIndex
    (
      const char* iName,
      const char* tName
    ) const
```

Parameters. Two parameters are required:

- The name of the index (*`iName`*)
- The name of the table to which the index belongs (*`tName`*)

Both of these are string values, represented by character pointers.

Return value. A pointer to an `Index`. See Section 2.3.11, "The Index Class", for information about this object.

2.3.4.28 Dictionary::getLogfileGroup()

Description. This method gets a `LogfileGroup` object, given the name of the logfile group.

Signature.

```
LogfileGroup getLogfileGroup
    (
      const char* name
    )
```

Parameters. The *`name`* of the logfile group.

Return value. An instance of `LogfileGroup`; see Section 2.3.13, "The LogfileGroup Class", for more information.

2.3.4.29 Dictionary::getNdbError()

Description. This method retrieves the most recent `NDB` API error.

Signature.

```
const struct NdbError& getNdbError
    (
      void
    ) const
```

Parameters. *None.*

Return value. A reference to an `NdbError` object. See Section 2.3.20, "The NdbError Structure".

2.3.4.30 Dictionary::getTable()

Description. This method can be used to access the table with a known name. See Section 2.3.37, "The Table Class".

Signature.

```
const Table* getTable
    (
      const char* name
    ) const
```

Parameters. The *`name`* of the table.

Return value. A pointer to the table, or `NULL` if there is no table with the *`name`* supplied.

2.3.4.31 Dictionary::getTablespace()

Description. Given either the name or ID of a tablespace, this method returns the corresponding `Tablespace` object.

Signatures. This method can be invoked in either of ways, as show here:

- Using the tablespace name:

```
Tablespace getTablespace
    (
      const char* name
    )
```

- Using the tablespace ID:

```
Tablespace getTablespace
    (
      Uint32 id
    )
```

Parameters. Either one of the following:

- The *`name`* of the tablespace, a string (as a character pointer)
- The unsigned 32-bit integer *`id`* of the tablespace

Return value. A `Tablespace` object, as discussed in Section 2.3.38, "The Tablespace Class".

2.3.4.32 Dictionary::getUndofile()

Description. This method gets an `Undofile` object, given the ID of the node where an undofile is located and the file system path to the file.

Signature.

```
Undofile getUndofile
    (
      Uint32      nodeId,
      const char* path
    )
```

Parameters. This method requires the following two arguments:

- The *`nodeId`* of the data node where the undofile is located; this value is passed as a 32-bit unsigned integer
- The *`path`* to the undofile on the node's file system (string as character pointer)

Return value. An instance of `Undofile`. For more information, see Section 2.3.39, "The Undofile Class".

2.3.4.33 Dictionary::hasSchemaTrans()

Description. Tells whether an NDB API schema transaction is ongoing.

Signature.

```
bool hasSchemaTrans
    (
      void
    ) const
```

Parameters. *None*.

Return value. Returns boolean `TRUE` if a schema transaction is in progress, otherwise `FALSE`.

2.3.4.34 Dictionary::initDefaultHashMap()

Description. Initialize a default hash map for a table.

Signature.

```
int initDefaultHashMap
    (
      HashMap& dst,
      Uint32 fragments
    )
```

or

```
int initDefaultHashMap
    (
      HashMap& dst,
      Uint32 buckets,
      Uint32 fragments
    )
```

Parameters. A reference to the hash map and the number of fragments. Optionally the number of buckets.

Return value. Returns 0 on success; on failure, returns -1 and sets an error.

2.3.4.35 Dictionary::invalidateIndex()

Description. This method is used to invalidate a cached index object.

Signature. The index invalidated by this method can be referenced either as an `Index` object (using a pointer), or by index name and table name, as shown here:

```
void invalidateIndex
    (
      const char* indexName,
      const char* tableName
    )

void invalidateIndex
    (
      const Index* index
    )
```

Parameters. The names of the index to be removed from the cache and the table to which it belongs (*`indexName`* and *`tableName`*, respectively), or a pointer to the corresponding `Index` object.

Return value. *None*.

2.3.4.36 DIctionary::invalidateTable()

Description. This method is used to invalidate a cached table object.

Signature.

```
void invalidateTable
    (
      const char* name
    )
```

It is also possibloe to use a `Table` object rather than the name of the table, as shown here:

```
void invalidateTable
    (
      const Table* table
    )
```

Parameters. The *name* of the table to be removed from the table cache, or a pointer to the corresponding `Table` object.

Return value. *None*.

2.3.4.37 Dictionary::listEvents()

Description. This method returns a list of all events defined within the dictionary.

Signature.

```
int listEvents
    (
      List& list
    )
```

Parameters. A reference to a `List` object. (See Section 2.3.14, “The List Class”.)

Return value. `0` on success; `-1` on failure.

2.3.4.38 Dictionary::listIndexes()

Description. This method is used to obtain a `List` of all the indexes on a table, given the table's name. (See Section 2.3.14, “The List Class”.)

Signature.

```
int listIndexes
    (
      List&       list,
      const char* table
) const
```

Parameters. `listIndexes()` takes two arguments, both of which are required:

- A reference to the `List` that contains the indexes following the call to the method
- The name of the *`table`* whose indexes are to be listed

Return value. `0` on success, `-1` on failure.

2.3.4.39 Dictionary::listObjects()

Description. This method is used to obtain a list of objects in the dictionary. It is possible to get all of the objects in the dictionary, or to restrict the list to objects of a single type.

Signature. This method has two signatures:

```
int listObjects
    (
      List&        list,
      Object::Type type = Object::TypeUndefined
    ) const
```

and

```
int listObjects
    (
      List&        list,
      Object::Type type,
      bool         fullyQualified
    ) const
```

Parameters. A reference to a `List` object is required—this is the list that contains the dictionary's objects after `listObjects()` is called. (See Section 2.3.14, “The List Class”.) An optional second argument *type* may be used to restrict the list to only those objects of the given type—that is, of the specified `Object::Type`. (See Section 2.3.31.6, “Object::Type”.) If *type* is not given, then the list contains all of the dictionary's objects.

You can also specify whether or not the object names in the *list* are fully qualified (that is, whether the object name includes the database, schema, and possibly the table name). If you specify *fullyQualified*, then you must also specify the *type*.

Return value. `0` on success, `-1` on failure.

2.3.4.40 Dictionary::prepareHashMap()

Description. Creates or retrieves a hash map suitable for alteration. Requires a schema transaction to be in progress; see Section 2.3.4.2, “Dictionary::beginSchemaTrans()”, for more information.

Signature.

```
int prepareHashMap
    (
      const Table& oldTable,
      Table& newTable
    )
```

or

```
int prepareHashMap
    (
      const Table& oldTable,
      Table& newTable,
      Uint32 buckets
    )
```

Parameters. References to the old and new tables. Optionally, a number of buckets.

Return value. Returns 0 on success; on failure, returns -1 and sets an error.

2.3.4.41 Dictionary::releaseRecord()

Description. This method is used to free an `NdbRecord` after it is no longer needed.

Signature.

```
void releaseRecord
    (
      NdbRecord* record
    )
```

Parameters. The `NdbRecord` to be cleaned up.

Return value. *None*.

Example. See Section 2.3.27, “The NdbRecord Interface”.

2.3.4.42 Dictionary::removeCachedTable()

Description. This method removes the specified table from the local cache.

Signature.

```
void removeCachedTable
    (
      const char* table
    )
```

Parameters. The name of the *table* to be removed from the cache.

Return value. *None*.

2.3.4.43 Dictionary::removeCachedIndex()

Description. This method removes the specified index from the local cache.

Signature.

```
void removeCachedIndex
    (
      const char* index,
      const char* table
    )
```

Parameters. The `removeCachedIndex()` method requires two arguments:

- The name of the *`index`* to be removed from the cache
- The name of the *`table`* in which the index is found

Return value. *None*.

2.3.5 The Element Structure

This section discusses the `Element` structure.

Parent class. `List`

Description. The `Element` structure models an element of a list; it is used to store an object in a `List` populated by the `Dictionary` methods `listObjects()`, `listIndexes()`, and `listEvents()`.

Attributes. An `Element` has the attributes shown in the following table:

Table 2.13 Name, type, initial value, and description of Element structure attributes

Attribute	Type	Initial Value	Description
`id`	`unsigned int`	`0`	The object's ID
`type`	`Object::Type`	`Object::TypeUndefined`	The object's type—see Section 2.3.31.6, "Object::Type" for possible values
`state`	`Object::State`	`Object::StateUndefined`	The object's state—see Section 2.3.31.3, "Object::State" for possible values
`store`	`Object::Store`	`Object::StoreUndefined`	How the object is stored—see Section 2.3.31.5, "Object::Store" for possible values
`database`	`char*`	`0`	The database in which the object is found
`schema`	`char*`	`0`	The schema in which the object is found
`name`	`char*`	`0`	The object's name

2.3.6 The Event Class

This section discusses the `Event` class, its methods and defined types.

Parent class. `NdbDictionary`

Child classes. *None*

Description. This class represents a database event in an NDB Cluster.

Methods. The following table lists the public methods of the `Event` class and the purpose or use of each method:

Table 2.14 Event class methods and descriptions

Name	Description
`Event()`	Class constructor
`~Event()`	Destructor
`addEventColumn()`	Adds a column on which events should be detected
`addEventColumns()`	Adds multiple columns on which events should be detected
`addTableEvent()`	Adds the type of event that should be detected
`getDurability()`	Gets the event's durability
`getEventColumn()`	Gets a column for which an event is defined
`getName()`	Gets the event's name
`getNoOfEventColumns()`	Gets the number of columns for which an event is defined
`getObjectId()`	Gets the event's object ID
`getObjectStatus()`	Gets the event's object status
`getObjectVersion()`	Gets the event's object version
`getReport()`	Gets the event's reporting options
`getTable()`	Gets the `Table` object on which the event is defined
`getTableEvent()`	Checks whether an event is to be detected
`getTableName()`	Gets the name of the table on which the event is defined
`mergeEvents()`	Sets the event's merge flag
`setDurability()`	Sets the event's durability
`setName()`	Sets the event's name
`setReport()`	The the event's reporting options
`setTable()`	Sets the `Table` object on which the event is defined

Improved Event API (NDB 7.4.3 and later). NDB 7.4.3 introduces an epoch-driven Event API that supercedes the earlier GCI-based model. The new version of the API also simplifies error detection and handling. These changes are realized in the NDB API by implementing a number of new methods for `Ndb` and `NdbEventOperation`, deprecating several other methods of both classes, and adding new type values to `TableEvent`.

Some of the new methods directly replace or stand in for deprecated methods, but not all of the deprecated methods map to new ones, some of which are entirely new. Old (deprecated) methods are shown in the first column of the following table, and new methods in the second column; old methods corresponding to new methods are shown in the same row.

Table 2.15 Deprecated and new Event API methods in the NDB API, NDB 7.4.3

Name	Description
NdbEventOperation::getEventType()	NdbEventOperation::getEventType2()
NdbEventOperation::getGCI()	NdbEventOperation::getEpoch
NdbEventOperation::getLatestGCI()	Ndb::getHighestQueuedEpoch()
NdbEventOperation::isOverrun()	None; use NdbEventOperation::getEventType2()
NdbEventOperation::hasError()	None; use NdbEventOperation::getEventType2()
NdbEventOperation::clearError()	None
None	NdbEventOperation::isEmptyEpoch()
None	NdbEventOperation::isErrorEpoch()
Ndb::pollEvents()	Ndb::pollEvents2()
Ndb::nextEvent()	Ndb::nextEvent2()
Ndb::getLatestGCI()	Ndb::getHighestQueuedEpoch()
Ndb::getGCIEventOperations()	Ndb::getNextEventOpInEpoch2()
Ndb::isConsistent()	None
Ndb::isConsistentGCI()	None

Error handling using the new API is accomplished by checking the value returned from getEventType2(), and is no longer handled using the methods hasError() and clearError(), which are now deprecated and subject to removal in a future release of NDB Cluster. In support of this change, the range of possible TableEvent types has been expanded by those listed here:

- TE_EMPTY: Empty epoch
- TE_INCONSISTENT: Inconsistent epoch; missing data or overflow
- TE_OUT_OF_MEMORY: Inconsistent data; event buffer out of memory or overflow

The result of these changes is that, in NDB 7.4.3 and later, you can check for errors while checking a table event's type, as shown here:

```
NdbDictionary::Event::TableEvent* error_type = 0;
NdbEventOperation* pOp = nextEvent2();

if (pOp->isErrorEpoch(error_type)
{
  switch (error_type)
  {
    case TE_INCONSISTENT :
      // Handle error/inconsistent epoch...
      break;

    case TE_OUT_OF_MEMORY :
      // Handle error/inconsistent data...
      break;

    //  ...
  }
}
```

For more information, see the detailed descriptions for the Ndb and NdbEventOperation methods shown in the table previously, as well as Section 2.3.6.23, “Event::TableEvent”.

Types. These are the public types of the Event class:

Table 2.16 Event class types and descriptions

Name	Description
`TableEvent()`	Represents the type of a table event
`EventDurability()`	Specifies an event's scope, accessibility, and lifetime
`EventReport()`	Specifies the reporting option for a table event

2.3.6.1 Event::addEventColumn()

Description. This method is used to add a column on which events should be detected. The column may be indicated either by its ID or its name.

> **Important**
>
> You must invoke `Dictionary::createEvent()` before any errors will be detected. See Section 2.3.4.4, “Dictionary::createEvent()”.

> **Note**
>
> If you know several columns by name, you can enable event detection on all of them at one time by using `addEventColumns()`. See Section 2.3.6.2, “Event::addEventColumns()”.

Signature. Identifying the event using its column ID:

```
void addEventColumn
    (
      unsigned attrId
    )
```

Identifying the column by name:

```
void addEventColumn
    (
      const char* columnName
    )
```

Parameters. This method takes a single argument, which may be either one of the following:

- The column ID (`attrId`), which should be an integer greater than or equal to `0`, and less than the value returned by `getNoOfEventColumns()`.
- The column's *`name`* (as a constant character pointer).

Return value. *None*.

2.3.6.2 Event::addEventColumns()

Description. This method is used to enable event detection on several columns at the same time. You must use the names of the columns.

> **Important**
>
> As with `addEventColumn()`, you must invoke `Dictionary::createEvent()` before any errors will be detected. See Section 2.3.4.4, “Dictionary::createEvent()”.

Signature.

```
void addEventColumns
    (
```

```
      int           n,
      const char** columnNames
    )
```

Parameters. This method requires two arguments, listed here:

- The number of columns `n` (an integer).
- The names of the columns `columnNames`—this must be passed as a pointer to a character pointer.

Return value. *None*.

2.3.6.3 Event::addTableEvent()

Description. This method is used to add types of events that should be detected.

Signature.

```
void addTableEvent
    (
      const TableEvent te
    )
```

Parameters. This method requires a `TableEvent` value.

Return value. *None*.

2.3.6.4 Event Constructor

Description. The `Event` constructor creates a new instance with a given name, and optionally associated with a table.

You should keep in mind that the NDB API does not track allocated event objects, which means that the user must explicitly delete the `Event` thus created after it is no longer in use.

Signatures. It is possible to invoke this method in either of two ways, the first of these being by name only, as shown here:

```
Event
    (
      const char* name
    )
```

Alternatively, you can use the event name and an associated table, like this:

```
Event
    (
      const char*                  name,
      const NdbDictionary::Table& table
    )
```

Parameters. At a minimum, a `name` (as a constant character pointer) for the event is required. Optionally, an event may also be associated with a table; this argument, when present, is a reference to a `Table` object (see Section 2.3.37, "The Table Class").

Return value. A new instance of `Event`.

Destructor. A destructor for this class is supplied as a virtual method which takes no arguments and whose return type is `void`.

2.3.6.5 Event::EventDurability

This section discusses `EventDurability`, a type defined by the `Event` class.

Description. The values of this type are used to describe an event's lifetime or persistence as well as its scope.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.17 Event::EventDurability data type values and descriptions

Name	Description
`ED_UNDEFINED`	The event is undefined or of an unsupported type.
`ED_SESSION`	This event persists only for the duration of the current session, and is available only to the current application. It is deleted after the application disconnects or following a cluster restart. **Important** The value `ED_SESSION` is reserved for future use and is not yet supported in any NDB Cluster release.
`ED_TEMPORARY`	Any application may use the event, but it is deleted following a cluster restart. **Important** The value `ED_TEMPORARY` is reserved for future use and is not yet supported in any NDB Cluster release.
`ED_PERMANENT`	Any application may use the event, and it persists until deleted by an application—even following a cluster. restart **Important** The value `ED_PERMANENT` is reserved for future use and is not yet supported in any NDB Cluster release.

2.3.6.6 Event::EventReport

This section discusses `EventReport`, a type defined by the `Event` class.

Description. The values of this type are used to specify reporting options for table events.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.18 Event::EventReport type values and descriptions

Name	Description
`ER_UPDATED`	Reporting of update events
`ER_ALL`	Reporting of all events, except for those not resulting in any updates to the inline parts of `BLOB` columns
`ER_SUBSCRIBE`	Reporting of subscription events
`ER_DDL`	Reporting of DDL events (see Section 2.3.6.20, “Event::setReport()”, for more information)

2.3.6.7 Event::getDurability()

Description. This method gets the event's lifetime and scope (that is, its `EventDurability`).

Signature.

```
EventDurability getDurability
    (
      void
    ) const
```

Parameters. *None*.

Return value. An `EventDurability` value.

2.3.6.8 Event::getEventColumn()

Description. This method is used to obtain a specific column from among those on which an event is defined.

Signature.

```
const Column* getEventColumn
    (
      unsigned no
    ) const
```

Parameters. The number (*no*) of the column, as obtained using `getNoOfColumns()` (see Section 2.3.6.10, "Event::getNoOfEventColumns()").

Return value. A pointer to the `Column` corresponding to *no*.

2.3.6.9 Event::getName()

Description. This method obtains the name of the event.

Signature.

```
const char* getName
    (
      void
    ) const
```

Parameters. *None*.

Return value. The name of the event, as a character pointer.

2.3.6.10 Event::getNoOfEventColumns()

Description. This method obtains the number of columns on which an event is defined.

Signature.

```
int getNoOfEventColumns
    (
      void
    ) const
```

Parameters. *None*.

Return value. The number of columns (as an integer), or `-1` in the case of an error.

2.3.6.11 Event::getObjectStatus()

Description. This method gets the object status of the event.

Signature.

```
virtual Object::Status getObjectStatus
    (
      void
    ) const
```

Parameters. *None*.

Return value. The object status of the event. For possible values, see Section 2.3.31.4, “Object::Status”.

2.3.6.12 Event::getObjectVersion()

Description. This method gets the event's object version (see NDB Schema Object Versions).

Signature.

```
virtual int getObjectVersion
    (
      void
    ) const
```

Parameters. *None*.

Return value. The object version of the event, as an integer.

2.3.6.13 Event::getObjectId()

Description. This method retrieves an event's object ID.

Signature.

```
virtual int getObjectId
    (
      void
    ) const
```

Parameters. *None*.

Return value. The object ID of the event, as an integer.

2.3.6.14 Event::getReport()

Description. This method is used to obtain the reporting option in force for this event.

Signature.

```
EventReport getReport
    (
      void
    ) const
```

Parameters. *None*.

Return value. One of the reporting options specified in Section 2.3.6.6, “Event::EventReport”.

2.3.6.15 Event::getTable()

Description. This method is used to find the table with which an event is associated. It returns a reference to the corresponding `Table` object. You may also obtain the name of the table directly using `getTableName()`.

Signature.

```
const NdbDictionary::Table* getTable
    (
      void
    ) const
```

Parameters. *None*.

Return value. The table with which the event is associated—if there is one—as a pointer to a `Table` object; otherwise, this method returns `NULL`. (See Section 2.3.37, “The Table Class”.)

2.3.6.16 Event::getTableEvent()

Description. This method is used to check whether a given table event will be detected.

Signature.

```
bool getTableEvent
    (
      const TableEvent te
    ) const
```

Parameters. This method takes a single parameter, the table event's type—that is, a `TableEvent` value.

Return value. This method returns `true` if events of `TableEvent` type *`te`* will be detected. Otherwise, the return value is `false`.

2.3.6.17 Event::getTableName()

Description. This method obtains the name of the table with which an event is associated, and can serve as a convenient alternative to `getTable()`. (See Section 2.3.6.15, “Event::getTable()”.)

Signature.

```
const char* getTableName
    (
      void
    ) const
```

Parameters. *None*.

Return value. The name of the table associated with this event, as a character pointer.

2.3.6.18 Event::mergeEvents()

Description. This method is used to set the *merge events flag*, which is `false` by default. Setting it to `true` implies that events are merged as follows:

- For a given `NdbEventOperation` associated with this event, events on the same primary key within the same global checkpoint index (GCI) are merged into a single event.
- A blob table event is created for each blob attribute, and blob events are handled as part of main table events.
- Blob post/pre data from blob part events can be read via `NdbBlob` methods as a single value.

> **Note**
>
> Currently this flag is not inherited by `NdbEventOperation`, and must be set on `NdbEventOperation` explicitly. See Section 2.3.21, “The NdbEventOperation Class”.

Signature.

```
void mergeEvents
    (
      bool flag
    )
```

Parameters. A Boolean `flag` value.

Return value. *None*.

2.3.6.19 Event::setDurability()

Description. This method sets an event's durability—that is, its lifetime and scope.

Signature.

```
void setDurability(EventDurability ed)
```

Parameters. This method requires a single `EventDurability` value as a parameter.

Return value. *None*.

2.3.6.20 Event::setReport()

Description. This method is used to set a reporting option for an event. Possible option values may be found in Section 2.3.6.6, “Event::EventReport”.

Reporting of DDL events. You must call `setReport()` using the `EventReport` value `ER_DDL` (added in the same NDB Cluster versions).

For example, to enable DDL event reporting on an `Event` object named `myEvent`, you must invoke this method as shown here:

```
myEvent.setReport(NdbDictionary::Event::ER_DDL);
```

Signature.

```
void setReport
    (
      EventReport er
    )
```

Parameters. An `EventReport` option value.

Return value. *None*.

2.3.6.21 Event::setName()

Description. This method is used to set the name of an event. The name must be unique among all events visible from the current application (see Section 2.3.6.7, “Event::getDurability()”).

> **Note**
>
> You can also set the event's name when first creating it. See Section 2.3.6.4, “Event Constructor”.

Signature.

```
void setName
    (
```

```
    const char* name
  )
```

Parameters. The *name* to be given to the event (as a constant character pointer).

Return value. *None*.

2.3.6.22 Event::setTable()

Description. This method defines a table on which events are to be detected.

> **Note**
>
> By default, event detection takes place on all columns in the table. Use `addEventColumn()` to override this behavior. For details, see Section 2.3.6.1, "Event::addEventColumn()".

Signature.

```
void setTable
  (
    const NdbDictionary::Table& table
  )
```

NDB 7.3.3 and later NDB Cluster releases support the use of a pointer with this method, as shown here:

```
void setTable
  (
    const NdbDictionary::Table*; table
  )
```

When so used, this version of `setTable()` returns -1 if the table pointer is `NULL`. (Bug #16329082)

Parameters. This method requires a single parameter, a reference to the table (see Section 2.3.37, "The Table Class") on which events are to be detected. *NDB 7.3.3 and later*: A reference or a pointer to the table can be used.

Return value. *None*. *NDB 7.3.3 and later*: -1, if a null table pointer is used.

2.3.6.23 Event::TableEvent

This section describes `TableEvent`, a type defined by the `Event` class.

Description. `TableEvent` is used to classify the types of events that may be associated with tables in the NDB API.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.19 Event::TableEvent type values and descriptions

Name	Description
`TE_INSERT`	Insert event on a table
`TE_DELETE`	Delete event on a table
`TE_UPDATE`	Update event on a table
`TE_DROP`	Occurs when a table is dropped
`TE_ALTER`	Occurs when a table definition is changed
`TE_CREATE`	Occurs when a table is created

Name	Description
`TE_GCP_COMPLETE`	Occurs on the completion of a global checkpoint
`TE_CLUSTER_FAILURE`	Occurs on Cluster failures
`TE_STOP`	Occurs when an event operation is stopped
`TE_NODE_FAILURE`	Occurs when a Cluster node fails
`TE_SUBSCRIBE`	Occurs when a cluster node subscribes to an event
`TE_UNSUBSCRIBE`	Occurs when a cluster node unsubscribes from an event
`TE_EMPTY`	Empty epoch received from data nodes
`TE_INCONSISTENT`	Missing data or buffer overflow at data node
`TE_OUT_OF_MEMORY`	Overflow in event buffer
`TE_ALL`	Occurs when any event occurs on a table (not relevant when a specific event is received)

`TE_EMPTY`, `TE_INCONSISTENT`, and `TE_OUT_OF_MEMORY` were added in NDB 7.4.3.

2.3.7 The EventBufferMemoryUsage Structure

This section describes the `EventBufferMemoryUsage` structure.

Parent class. `Ndb`

Description. This structure was added in NDB 7.4.3 for working with event buffer memory usage statistics. It is used as an argument to `Ndb::get_event_buffer_memory_usage()`.

Attributes. `EventBufferMemoryUsage` has the attributes shown in the following table:

Table 2.20 EventBufferMemoryUsage structure attributes, with types, initial values, and descriptions

Name	Type	Initial Value	Description
`allocated_bytes`	`unsigned`	*none*	The total event buffer memory allocated, in bytes
`used_bytes`	`unsigned`	*none*	The total memory used, in bytes
`usage_percent`	`unsigned`	*none*	Event buffer memory usage, as a percent (`100 * used_bytes / allocated_bytes`)

2.3.8 The ForeignKey Class

This class represents a foreign key on an `NDB` table. It was added to the NDB API in NDB Cluster 7.3.

Parent class. `Object`

Child classes. *None*.

Methods. The following table lists the public methods of the `ForeignKey` class and the purpose or use of each method:

Table 2.21 ForeignKey class methods and descriptions

Name	Description
`ForeignKey()`	Class constructor

Name	Description
~ForeignKey()	Class destructor
getName()	Get the foreign key's name
getParentTable()	Get the foreign key's parent table
getChildTable()	Get the foreign key's child table
getParentColumnCount()	Get the number of columns in the parent table
getChildColumnCount()	Get the number of columns in the child table
getParentColumnNo()	Get the column number in the parent table
getChildColumnNo()	Get the column number in the child table
getParentIndex()	Returns 0 if key points to parent table's primary key
getChildIndex()	Returns 0 if child references resolved using child table's primary key
getOnUpdateAction()	Get the foreign's key update action (FkAction)
getOnDeleteAction()	Get the foreign key's delete action (FkAction)
setName()	Set the foreign key's name
setParent()	Set the foreign key's parent table
setChild()	Set a foreign key's child table
setOnUpdateAction()	Set the foreign's key update action (FkAction)
setOnDeleteAction()	Set the foreign key's delete action (FkAction)
getObjectStatus()	Get the object status
getObjectId()	Get the object ID
getObjectVersion()	Get the object version

Types. The ForeignKey class has one public type, the FkAction type.

2.3.8.1 ForeignKey()

Description. Create either an entirely new foreign key reference, or a copy of an existing one.

Signature. New instance:

```
ForeignKey
    (
      void
    )
```

Copy constructor:

```
ForeignKey
    (
      const ForeignKey&
    )
```

Parameters. For a new instance: *None*.

For the copy constructor: A reference to an existing instance of ForeignKey.

Return value. A new instance of ForeignKey.

2.3.8.2 ForeignKey::FkAction

FkAction is an enumeration which represents a reference action for a foreign key when an update or delete operation is performed on the parent table.

Enumeration values. Possible values are shown, along with the corresponding reference action, in the following table:

Table 2.22 ForeignKey::FkAction data type values and descriptions

Name	Description
`NoAction`	`NO ACTION`: Deferred check.
`Restrict`	`RESTRICT`: Reject operation on parent table.
`Cascade`	`CASCADE`: Perform operation on row from parent table; perform same operation on matching rows in child table.
`SetNull`	`SET NULL`: Perform operation on row from parent table; set any matching foreign key columns in child table to `NULL`.
`SetDefault`	`SET DEFAULT`: Currently not supported in NDB Cluster.

See also FOREIGN KEY Constraints, in the *MySQL Manual*.

2.3.8.3 ForeignKey::getName()

Description. Retrieve the name of the `ForeignKey` instance for which the method is invoked.

Signature.

```
const char* getName
    (
      void
    ) const
```

Parameters. *None*.

Return value. The name of the `ForeignKey`.

2.3.8.4 ForeignKey::getParentTable()

Description. Retrieve the parent table of the `ForeignKey` instance for which the method is invoked.

Signature.

```
const char* getParentTable
      (
        void
      ) const
```

Parameters. *None*.

Return value. A pointer to the parent table of the `ForeignKey`.

2.3.8.5 ForeignKey::getChildTable()

Description. Retrieve the child table of the `ForeignKey` instance for which the method is invoked.

Signature.

```
const char* getChildTable
      (
        void
      ) const
```

Parameters. *None*.

Return value. A pointer to the child table of this `ForeignKey`.

2.3.8.6 ForeignKey::getParentColumnCount()

Description. Retrieve the number of columns in the parent table of this `ForeignKey`.

Signature.

```
unsigned getParentColumnCount
      (
        void
      ) const
```

Parameters. *None*.

Return value. The number of columns in the parent table.

2.3.8.7 ForeignKey::getChildColumnCount()

Description. Retrieve the number of columns in the child table of this `ForeignKey`.

Signature.

```
unsigned getChildColumnCount
      (
        void
      ) const
```

Parameters. *None*.

Return value. The number of columns in the child table.

2.3.8.8 ForeignKey::getParentIndex()

Description. Returns 0 if the child table refers to the parent table's primary key.

Signature.

```
const char* getParentIndex
    (
      void
    ) const
```

Parameters. *None*.

Return value. See description.

2.3.8.9 ForeignKey::getChildIndex()

Description. Return 0 if child references are resolved using the child table's primary key.

Signature.

```
const char* getChildIndex
    (
      void
    ) const
```

Parameters. *None*.

Return value. See description.

2.3.8.10 ForeignKey::getParentColumnNo()

Description. This method gets the sequence number of a foreign key column in the parent table for a given index. See the documentation for `Column::getColumnNo()` for information about handling columns in the NDB API.

Signature.

```
int getParentColumnNo
    (
      unsigned no
    ) const
```

Parameters. *None*.

Return value. The sequence number of the column.

2.3.8.11 ForeignKey::getChildColumnNo()

Description. This method gets the sequence number of a foreign key column in the child table for a given index. See the documentation for `Column::getColumnNo()` for information about handling columns in the NDB API.

Signature.

```
int getChildColumnNo
    (
      unsigned no
    ) const
```

Parameters. *None*.

Return value. The sequence number of the column.

2.3.8.12 ForeignKey::getOnUpdateAction()

Description. Get the foreign key's `ON UPDATE` action. This is a `ForeignKey::FkAction` and has one of the values `NoAction`, `Restrict`, `Cascade`, or `SetNull`.

Signature.

```
FkAction getOnUpdateAction
    (
      void
    ) const
```

Parameters. *None*.

Return value. The sequence number of the column.

2.3.8.13 ForeignKey::getOnDeleteAction()

Description. Get the foreign key's `ON DELETE` action. This is a `ForeignKey::FkAction` and has one of the values `NoAction`, `Restrict`, `Cascade`, or `SetNull`.

Signature.

```
FkAction getOnDeleteAction
    (
      void
    ) const
```

Parameters. *None*.

Return value. The sequence number of the column.

2.3.8.14 ForeignKey::setName()

Description. Set the name of the `ForeignKey` instance for which the method is invoked.

Signature.

```
void setName
    (
      const char*
    )
```

Parameters. The name of the `ForeignKey`.

Return value. *None*.

2.3.8.15 ForeignKey::setParent()

Description. Set the parent table of a `ForeignKey`, given a reference to the table, and optionally, an index to use as the foreign key.

Signature.

```
void setParent
    (
      const Table&,
      const Index* index = 0,
      const Column* cols[] = 0
    )
```

Parameters. A reference to a `Table`. Optionally, an index using the indicated column or columns.

Return value. *None*.

2.3.8.16 ForeignKey::setChild()

Description. Set the child table of a `ForeignKey`, given a reference to the table, and optionally, an index to use as the foreign key.

Signature.

```
void setChild
    (
      const Table&,
      const Index* index = 0,
      const Column* cols[] = 0
    )
```

Parameters. A reference to a `Table`. Optionally, an index using the indicated column or columns.

Return value. *None*.

2.3.8.17 ForeignKey::setOnUpdateAction()

Description. Set the foreign key's `ON UPDATE` action.

Signature.

```
void setOnUpdateAction
  (
    FkAction
  )
```

Parameters. The `ON UPDATE` action to be performed. This must be a `ForeignKey::FkAction` having one of the values `NoAction`, `Restrict`, `Cascade`, or `SetNull`.

Return value. *None*

2.3.8.18 ForeignKey::setOnDeleteAction()

Description. Set the foreign key's `ON DELETE` action.

Signature.

```
void setOnUpdateAction
  (
    FkAction
  )
```

Parameters. The `ON UPDATE` action to be performed, of type `ForeignKey::FkAction`. Must be one of the values `NoAction`, `Restrict`, `Cascade`, or `SetNull`.

Return value. *None*

2.3.8.19 ForeignKey::getObjectStatus()

Description. Get the object status (see Section 2.3.31.4, "Object::Status") for this `ForeignKey` object.

Signature.

```
virtual Object::Status getObjectStatus
    (
      void
    ) const
```

Parameters. *None*.

Return value. The `ForeignKey` object's status, as a value of type `Object::Status`. See this type's documentation for possible values and their interpretation.

2.3.8.20 ForeignKey::getObjectId()

Description. Get the object ID (see Section 2.3.31.7, "Object::getObjectId()") for this `ForeignKey` object.

Signature.

```
virtual int getObjectId
    (
      void
    ) const
```

Parameters. *None*.

Return value. The `ForeignKey` object's ID, as returned by `Object::getObjectId()`.

2.3.8.21 ForeignKey::getObjectVersion()

Description. Get the object version (see Section 2.3.31.9, "Object::getObjectVersion()") for this `ForeignKey` object.

Signature.

```
virtual int getObjectVersion
```

```
(
  void
) const
```

Parameters. *None*.

Return value. The `ForeignKey` object's version number (an integer), as returned by `Object::getObjectVersion()`.

2.3.9 The GetValueSpec Structure

Parent class. `NdbOperation`

Description. This structure is used to specify an extra value to obtain as part of an `NdbRecord` operation.

Members. The elements making up this structure are shown in the following table:

Table 2.23 GetValueSpec structure member names, types, and descriptions

Name	Type	Description
`column`	`const Column*`	To specify an extra value to read, the caller must provide this, as well as (optionally `NULL`) *`appStorage`* pointer.
`appStorage`	`void*`	If this pointer is null, then the received value is stored in memory managed by the `NdbRecAttr` object. Otherwise, the received value is stored at the location pointed to (and is still accessable using the `NdbRecAttr` object). **Important** It is the caller's responsibility to ensure that the following conditions are met: 1. *`appStorage`* points to sufficient space to store any returned data. 2. Memory pointed to by *`appStorage`* is not reused or freed until after the `execute()` call returns.
`recAttr`	`NdbRecAttr*`	After the operation is defined, *`recAttr`* contains a pointer to the `NdbRecAttr` object for receiving the data.

Important

Currently, blob reads cannot be specified using `GetValueSpec`.

For more information, see Section 2.3.27, “The NdbRecord Interface”.

2.3.10 The HashMap Class

This class represents a hash map in an NDB Cluster.

Parent class. `Object`

Child classes. *None*.

Methods. The following table lists the public methods of the `HashMap` class and the purpose or use of each method:

Table 2.24 HashMap class methods and descriptions

Name	Description
`HashMap()`	Class constructor
`~HashMap()`	Class destructor
`setName()`	Set a name for the hashmap
`getName()`	Gets a hashmap's name
`setMap()`	Sets a hashmap's length and values
`getMapLen()`	Gets a hashmap's length
`getMapValues()`	Gets the values contained in the hashmap
`equal()`	Compares this hashmap's values with those of another hashmap
`getObjectStatus()`	Gets the hashmap's object status
`getObjectVersion()`	Gets the hashmap's schema object version
`getObjectId()`	Gets the hashmap's ID

Types. The `HashMap` class has no public types.

2.3.10.1 HashMap Constructor

Description. The `HashMap` class constructor normally requires no arguments. A copy constructor is also available.

See also Section 2.3.4.6, “Dictionary::createHashMap()”, for more information.

Signature. Base constructor:

```
HashMap HashMap
    (
      void
    )
```

Copy constructor:

```
HashMap HashMap
    (
      const HashMap& hashmap
    )
```

Destructor:

```
virtual ~HashMap
    (
      void
    )
```

Parameters. *None*, or the address of an existing `HashMap` object to be copied.

Return value. A new instance of `HashMap`, possibly a copy of an existing one.

2.3.10.2 HashMap::setName()

Description. Sets the name of the hash map.

Signature.

```
void setName
    (
      const char* name
    )
```

Parameters. The name to be assigned to the hashmap.

Return value. *None*.

2.3.10.3 HashMap::getName()

Description. Gets the name of the hash map.

Signature.

```
const char* getName
    (
      void
    ) const
```

Parameters. *None*.

Return value. The name of the hash map.

2.3.10.4 HashMap::setMap()

Description. Assigns a set of values to a has map.

Signature.

```
void setMap
    (
      const Uint32* values,
      Uint32 len
    )
```

Parameters. A pointer to a set of `values` of length `len`.

Return value. *None*.

2.3.10.5 HashMap::getMapLen()

Description. Gets the hash map's length; that is, the number of values which it contains. You can obtain the values using `getMapValues()`.

Signature.

```
Uint32 getMapLen
    (
      void
    ) const
```

Parameters. *None*.

Return value. The length of the hash map.

2.3.10.6 HashMap::getMapValues()

Description. Gets the values listed in the hash map.

Signature.

```
int getMapValues
    (
      Uint32* dst,
      Uint32 len
    ) const
```

Parameters. A pointer to a set of values (`dst`) and the number of values (`len`).

Return value. Returns 0 on success; on failure, returns -1 and sets error.

2.3.10.7 HashMap::equal()

Description. Compares (only) the values of this `HashMap` with those of another one.

Signature.

```
bool equal
    (
      const HashMap& hashmap
    ) const
```

Parameters. A reference to the hash map to be compared with this one.

Return value. *None*.

2.3.10.8 HashMap::getObjectStatus()

Description. This method retrieves the status of the `HashMap` for which it is invoked. The return value is of type `Object::Status`.

Signature.

```
virtual Status getObjectStatus
    (
      void
    ) const
```

Parameters. *None*.

Return value. Returns the current `Status` of the `HashMap`.

2.3.10.9 HashMap::getObjectVersion()

Description. The method gets the hash map's schema object version.

Signature.

```
virtual int getObjectVersion
    (
      void
    ) const
```

Parameters. *None*.

Return value. The object's version number, an integer.

2.3.10.10 HashMap::getObjectId()

Description. This method retrieves the hash map's ID.

Signature.

```
virtual int getObjectId
    (
      void
    ) const
```

Parameters. *None*.

Return value. The object ID, an integer.

2.3.11 The Index Class

This section provides a reference to the `Index` class and its public members.

Parent class. `NdbDictionary`

Child classes. *None*

Description. This class represents an index on an `NDB Cluster` table column. It is a descendant of the `NdbDictionary` class, using the `Object` class.

Methods. The following table lists the public methods of `Index` and the purpose or use of each method:

Table 2.25 Index class methods and descriptions

Name	Description
`Index()`	Class constructor
`~Index()`	Destructor
`addColumn()`	Adds a `Column` object to the index
`addColumnName()`	Adds a column by name to the index
`addColumnNames()`	Adds multiple columns by name to the index
`getColumn()`	Gets a column making up (part of) the index
`getLogging()`	Checks whether the index is logged to disk
`getName()`	Gets the name of the index
`getNoOfColumns()`	Gets the number of columns belonging to the index
`getObjectStatus()`	Gets the index object status
`getObjectVersion()`	Gets the index object status
`getObjectId()`	Gets the index object ID
`getTable()`	Gets the name of the table being indexed
`getType()`	Gets the index type
`setLogging()`	Enable/disable logging of the index to disk
`setName()`	Sets the name of the index
`setTable()`	Sets the name of the table to be indexed
`setType()`	Set the index type

Types. Index has one public type, the `Type` type.

Important

If you create or change indexes using the `NDB` API, these modifications cannot be seen by MySQL. The only exception to this is renaming the index using `Index::setName()`.

2.3.11.1 Index Class Constructor

Description. This is used to create an new instance of `Index`.

Important

Indexes created using the NDB API cannot be seen by the MySQL Server.

Signature.

```
Index
    (
      const char* name = ""
    )
```

Parameters. The name of the new index. It is possible to create an index without a name, and then assign a name to it later using `setName()`. See Section 2.3.11.15, “Index::setName()”.

Return value. A new instance of `Index`.

Destructor. The destructor (`~Index()`) is supplied as a virtual method.

2.3.11.2 Index::addColumn()

Description. This method may be used to add a column to an index.

Note

The order of the columns matches the order in which they are added to the index. However, this matters only with ordered indexes.

Signature.

```
void addColumn
    (
      const Column& c
    )
```

Parameters. A reference *c* to the column which is to be added to the index.

Return value. *None*.

2.3.11.3 Index::addColumnName()

Description. This method works in the same way as `addColumn()`, except that it takes the name of the column as a parameter. See Section 2.3.11.5, “Index::getColumn()”.

Signature.

```
void addColumnName
    (
      const char* name
    )
```

Parameters. The *name* of the column to be added to the index, as a constant character pointer.

Return value. *None*.

2.3.11.4 Index::addColumnNames()

Description. This method is used to add several column names to an index definition at one time.

Note

As with the `addColumn()` and `addColumnName()` methods, the indexes are numbered in the order in which they were added. (However, this matters only for ordered indexes.)

Signature.

```
void addColumnNames
    (
      unsigned     noOfNames,
      const char** names
    )
```

Parameters. This method takes two parameters, listed here:

- The number of columns and names *`noOfNames`* to be added to the index.
- The *`names`* to be added (as a pointer to a pointer).

Return value. *None*.

2.3.11.5 Index::getColumn()

Description. This method retrieves the column at the specified position within the index.

Signature.

```
const Column* getColumn
    (
      unsigned no
    ) const
```

Parameters. The ordinal position number *`no`* of the column, as an unsigned integer. Use the `getNoOfColumns()` method to determine how many columns make up the index—see Section 2.3.11.8, "Index::getNoOfColumns()", for details.

Return value. The column having position *`no`* in the index, as a pointer to an instance of `Column`. See Section 2.3.2, "The Column Class".

2.3.11.6 Index::getLogging()

Description. Use this method to determine whether logging to disk has been enabled for the index.

Note

Indexes which are not logged are rebuilt when the cluster is started or restarted.

Ordered indexes currently do not support logging to disk; they are rebuilt each time the cluster is started. (This includes restarts.)

Signature.

```
bool getLogging
    (
      void
```

```
    ) const
```

Parameters. *None*.

Return value. A Boolean value:

- `true`: The index is being logged to disk.
- `false`: The index is not being logged.

2.3.11.7 Index::getName()

Description. This method is used to obtain the name of an index.

Signature.

```
const char* getName
    (
      void
    ) const
```

Parameters. *None*.

Return value. The name of the index, as a constant character pointer.

2.3.11.8 Index::getNoOfColumns()

Description. This method is used to obtain the number of columns making up the index.

Signature.

```
unsigned getNoOfColumns
    (
      void
    ) const
```

Parameters. *None*.

Return value. An unsigned integer representing the number of columns in the index.

2.3.11.9 Index::getObjectStatus()

Description. This method gets the object status of the index.

Signature.

```
virtual Object::Status getObjectStatus
    (
      void
    ) const
```

Parameters. *None*.

Return value. A `Status` value—see Section 2.3.31.4, "Object::Status", for more information.

2.3.11.10 Index::getObjectVersion()

Description. This method gets the object version of the index (see NDB Schema Object Versions).

Signature.

```
virtual int getObjectVersion
```

```
    (
      void
    ) const
```

Parameters. *None*.

Return value. The object version for the index, as an integer.

2.3.11.11 Index::getObjectId()

Description. This method is used to obtain the object ID of the index.

Signature.

```
virtual int getObjectId
    (
      void
    ) const
```

Parameters. *None*.

Return value. The object ID, as an integer.

2.3.11.12 Index::getTable()

Description. This method can be used to obtain the name of the table to which the index belongs.

Signature.

```
const char* getTable
    (
      void
    ) const
```

Parameters. *None*.

Return value. The name of the table, as a constant character pointer.

2.3.11.13 Index::getType()

Description. This method can be used to find the type of index.

Signature.

```
Type getType
    (
      void
    ) const
```

Parameters. *None*.

Return value. An index type. See Section 2.3.11.18, “Index::Type”, for possible values.

2.3.11.14 Index::setLogging

Description. This method is used to enable or disable logging of the index to disk.

Signature.

```
void setLogging
    (
      bool enable
```

```
    )
```

Parameters. `setLogging()` takes a single Boolean parameter *`enable`*. If *`enable`* is `true`, then logging is enabled for the index; if false, then logging of this index is disabled.

Return value. *None*.

2.3.11.15 Index::setName()

Description. This method sets the name of the index.

> **Note**
>
> This is the only `Index::set*()` method whose result is visible to a MySQL Server.

Signature.

```
void setName
    (
      const char* name
    )
```

Parameters. The desired *`name`* for the index, as a constant character pointer.

Return value. *None*.

2.3.11.16 Index::setTable()

Description. This method sets the table that is to be indexed. The table is referenced by name.

Signature.

```
void setTable
    (
      const char* name
    )
```

Parameters. The *`name`* of the table to be indexed, as a constant character pointer.

Return value. *None*.

2.3.11.17 Index::setType()

Description. This method is used to set the index type.

Signature.

```
void setType
    (
      Type type
    )
```

Parameters. The *`type`* of index. For possible values, see Section 2.3.11.18, “Index::Type”.

Return value. *None*.

2.3.11.18 Index::Type

Description. This is an enumerated type which describes the sort of column index represented by a given instance of `Index`.

Caution

Do not confuse this enumerated type with `Object::Type`, or with `Column::Type`.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.26 Index::Type data type values and descriptions

Name	Description
`Undefined`	Undefined object type (initial/default value)
`UniqueHashIndex`	Unique unordered hash index (only index type currently supported)
`OrderedIndex`	Nonunique, ordered index

2.3.12 The IndexBound Structure

Parent class. `NdbIndexScanOperation`

Description. `IndexBound` is a structure used to describe index scan bounds for `NdbRecord` scans.

Members. These are shown in the following table:

Table 2.27 IndexBound structure member names, types, and descriptions

Name	Type	Description
`low_key`	`const char*`	Row containing lower bound for scan (or `NULL` for scan from the start).
`low_key_count`	`Uint32`	Number of columns in lower bound (for bounding by partial prefix).
`low_inclusive`	`bool`	True for `<=` relation, false for `<`.
`high_key`	`const char*`	Row containing upper bound for scan (or `NULL` for scan to the end).
`high_key_count`	`Uint32`	Number of columns in upper bound (for bounding by partial prefix).
`high_inclusive`	`bool`	True for `>=` relation, false for `>`.
`range_no`	`Uint32`	Value to identify this bound; may be read using the `get_range_no()` method (see Section 2.3.23.4, “NdbIndexScanOperation::get_range_no()”). This value must be less than 8192 (set to zero if it is not being used). For ordered scans, `range_no` must be strictly increasing for each range, or else the result set will not be sorted correctly.

For more information, see Section 2.3.27, “The NdbRecord Interface”.

2.3.13 The LogfileGroup Class

This section discusses the `LogfileGroup` class, which represents an NDB Cluster Disk Data logfile group.

Parent class. `NdbDictionary`

Child classes. *None*

Description. This class represents an NDB Cluster Disk Data logfile group, which is used for storing Disk Data undofiles. For general information about logfile groups and undofiles, see NDB Cluster Disk Data Tables, in the MySQL Manual.

> **Note**
>
> Only unindexed column data can be stored on disk. Indexes and indexes columns are always stored in memory.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.28 LogfileGroup class methods and descriptions

Name	Description
`LogfileGroup()`	Class constructor
`~LogfileGroup()`	Virtual destructor
`getAutoGrowSpecification()`	Gets the logfile group's `AutoGrowSpecification` values
`getName()`	Retrieves the logfile group's name
`getObjectId()`	Get the object ID of the logfile group
`getObjectStatus()`	Gets the logfile group's object status value
`getObjectVersion()`	Retrieves the logfile group's object version
`getUndoBufferSize()`	Gets the size of the logfile group's `UNDO` buffer
`getUndoFreeWords()`	Retrieves the amount of free space in the `UNDO` buffer
`setAutoGrowSpecification()`	Sets `AutoGrowSpecification` values for the logfile group
`setName()`	Sets the name of the logfile group
`setUndoBufferSize()`	Sets the size of the logfile group's `UNDO` buffer.

Types. The `LogfileGroup` class does not itself define any public types. However, two of its methods make use of the `AutoGrowSpecification` data structure as a parameter or return value. For more information, see Section 2.3.1, “The AutoGrowSpecification Structure”.

2.3.13.1 LogfileGroup Constructor

Description. The `LogfileGroup` class has two public constructors, one of which takes no arguments and creates a completely new instance. The other is a copy constructor.

> **Note**
>
> The `Dictionary` class also supplies methods for creating and destroying `LogfileGroup` objects. See Section 2.3.4, “The Dictionary Class”.

Signatures. New instance:

```
LogfileGroup
    (
      void
    )
```

Copy constructor:

```
LogfileGroup
    (
      const LogfileGroup& logfileGroup
```

```
    )
```

Parameters. When creating a new instance, the constructor takes no parameters. When copying an existing instance, the constructor is passed a reference to the `LogfileGroup` instance to be copied.

Return value. A `LogfileGroup` object.

Destructor.

```
virtual ~LogfileGroup
    (
      void
    )
```

Examples.

```
[To be supplied...]
```

2.3.13.2 LogfileGroup::getAutoGrowSpecification()

Description. This method retrieves the `AutoGrowSpecification` associated with the logfile group.

Signature.

```
const AutoGrowSpecification& getAutoGrowSpecification
    (
      void
    ) const
```

Parameters. *None*.

Return value. An `AutoGrowSpecification` data structure. See Section 2.3.1, “The AutoGrowSpecification Structure”, for details.

2.3.13.3 LogfileGroup::getName()

Description. This method gets the name of the logfile group.

Signature.

```
const char* getName
    (
      void
    ) const
```

Parameters. *None*.

Return value. The logfile group's name, a string (as a character pointer).

Example.

```
[To be supplied...]
```

2.3.13.4 LogfileGroup::getObjectId()

Description. This method is used to retrieve the object ID of the logfile group.

Signature.

```
virtual int getObjectId
    (
      void
```

```
    ) const
```

Parameters. *None*.

Return value. The logfile group's object ID (an integer value).

2.3.13.5 LogfileGroup::getObjectStatus()

Description. This method is used to obtain the object status of the `LogfileGroup`.

Signature.

```
virtual Object::Status getObjectStatus
    (
      void
    ) const
```

Parameters. *None*.

Return value. The logfile group's `Status`—see Section 2.3.31.4, “Object::Status” for possible values.

2.3.13.6 LogfileGroup::getObjectVersion()

Description. This method gets the logfile group's object version (see NDB Schema Object Versions).

Signature.

```
virtual int getObjectVersion
    (
      void
    ) const
```

Parameters. *None*.

Return value. The object version of the logfile group, as an integer.

2.3.13.7 LogfileGroup::getUndoBufferSize()

Description. This method retrieves the size of the logfile group's `UNDO` buffer.

Signature.

```
Uint32 getUndoBufferSize
    (
      void
    ) const
```

Parameters. *None*.

Return value. The size of the `UNDO` buffer, in bytes.

Example.

```
[To be supplied...]
```

2.3.13.8 LogfileGroup::getUndoFreeWords()

Description. This method retrieves the number of bytes unused in the logfile group's `UNDO` buffer.

Signature.

```
Uint64 getUndoFreeWords
```

```
    (
      void
    ) const
```

Parameters. *None*.

Return value. The number of bytes free, as a 64-bit integer.

Example.

```
[To be supplied...]
```

2.3.13.9 LogfileGroup::setAutoGrowSpecification()

Description. This method sets the `AutoGrowSpecification` data for the logfile group.

Signature.

```
void setAutoGrowSpecification
    (
      const AutoGrowSpecification& autoGrowSpec
    )
```

Parameters. The data is passed as a single parameter, an `AutoGrowSpecification` data structure—see Section 2.3.1, “The AutoGrowSpecification Structure”.

Return value. *None*.

2.3.13.10 LogfileGroup::setName()

Description. This method is used to set a name for the logfile group.

Signature.

```
void setName
    (
      const char* name
    )
```

Parameters. The *`name`* to be given to the logfile group (character pointer).

Return value. *None*.

Example.

```
[To be supplied...]
```

2.3.13.11 LogfileGroup::setUndoBufferSize()

Description. This method can be used to set the size of the logfile group's `UNDO` buffer.

Signature.

```
void setUndoBufferSize
    (
      Uint32 size
    )
```

Parameters. The *`size`* in bytes for the `UNDO` buffer (using a 32-bit unsigned integer value).

Return value. *None*.

Example.

```
[To be supplied...]
```

2.3.14 The List Class

This section covers the `List` class.

Parent class. Dictionary

Child classes. *None*

Description. The `List` class is a `Dictionary` subclass that is used for representing lists populated by the methods `Dictionary::listObjects()`, `Dictionary::listIndexes()`, and `Dictionary::listEvents()`.

Class Methods. This class has only two methods, a constructor and a destructor. Neither method takes any arguments.

Constructor. Calling the `List` constructor creates a new `List` whose `count` and `elements` attributes are both set equal to `0`.

Destructor. The destructor `~List()` is simply defined in such a way as to remove all elements and their properties. You can find its definition in the file `/storage/ndb/include/ndbapi/NdbDictionary.hpp`.

Attributes. A `List` has the following two attributes:

- `count`, an unsigned integer, which stores the number of elements in the list.
- `elements`, a pointer to an array of `Element` data structures contained in the list. See Section 2.3.5, “The Element Structure”.

Types. The `List` class also defines an `Element` structure.

2.3.15 The Key_part_ptr Structure

This section describes the `Key_part_ptr` structure.

Parent class. `Ndb`

Description. `Key_part_ptr` provides a convenient way to define key-part data when starting transactions and computing hash values, by passing in pointers to distribution key values. When the distribution key has multiple parts, they should be passed as an array, with the last part's pointer set equal to `NULL`. See Section 2.3.16.35, “Ndb::startTransaction()”, and Section 2.3.16.3, “Ndb::computeHash()”, for more information about how this structure is used.

Attributes. A `Key_part_ptr` has the attributes shown in the following table:

Table 2.29 Key_part_ptr structure attributes, with types, initial values, and descriptions

Attribute	Type	Initial Value	Description
`ptr`	`const void*`	*none*	Pointer to one or more distribution key values
`len`	`unsigned`	*none*	The length of the pointer

2.3.16 The Ndb Class

This class represents the `NDB` kernel; it is the primary class of the NDB API.

Parent class. *None*

Child classes. *None*

Description. Any nontrivial NDB API program makes use of at least one instance of Ndb. By using several Ndb objects, it is possible to implement a multithreaded application. You should remember that one Ndb object cannot be shared between threads; however, it is possible for a single thread to use multiple Ndb objects. A single application process can support a maximum of 4711 Ndb objects.

Resource consumption by Ndb objects. An Ndb object consumes memory in proportion to the size of the largest operation performed over the lifetime of the object. This is particularly noticeable in cases of large transactions; use of one or both of BLOB or TEXT columns; or both. This memory is held for the lifetime of the object, and once used in this way by the Ndb object, the only way to free this memory is to destroy the object (and then to create a new instance if desired).

Note

The Ndb object is multithread safe in that each Ndb object can be handled by one thread at a time. If an Ndb object is handed over to another thread, then the application must ensure that a memory barrier is used to ensure that the new thread sees all updates performed by the previous thread.

Semaphores and mutexes are examples of easy ways to provide memory barriers without having to bother about the memory barrier concept.

It is also possible to use multiple Ndb objects to perform operations on different clusters in a single application. See Application-level partitioning, for conditions and restrictions applying to such usage.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.30 Ndb class methods and descriptions

Name	Description
Ndb()	Class constructor; represents a connection to an NDB Cluster.
~Ndb()	Class destructor; terminates a Cluster connection when it is no longer to be used
closeTransaction()	Closes a transaction.
computeHash()	Computes a distribution hash value.
createEventOperation()	Creates a subscription to a database event. (See Section 2.3.21, “The NdbEventOperation Class”.)
dropEventOperation()	Drops a subscription to a database event.
getDictionary()	Gets a dictionary, which is used for working with database schema information.
getDatabaseName()	Gets the name of the current database.
getDatabaseSchemaName()	Gets the name of the current database schema.
get_eventbuf_max_alloc()	Gets the current allocated maximum size of the event buffer. Added in NDB 7.3.3.
get_eventbuffer_free_percent()	Gets the percentage of event buffer memory that should be available before buffering resumes, once the limit has been reached. Added in NDB 7.4.3.
get_event_buffer_memory_usage()	Provides event buffer memory usage information. Added in NDB 7.4.3.
getGCIEventOperations()	Gets the next event operation from a GCI. Deprecated in NDB 7.4.3.

Name	Description
getHighestQueuedEpoch()	Gets the latest epoch in the event queue. Added in NDB 7.4.3.
getLatestGCI()	Gets the most recent GCI. Deprecated in NDB 7.4.3.
getNdbError()	Retrieves an error. (See Section 2.3.20, “The NdbError Structure”.)
getNdbErrorDetail()	Retrieves extra error details.
getNdbObjectName()	Retrieves the Ndb object name if one was set. Added in NDB 7.3.6.
getNextEventOpInEpoch2()	Gets the next event operation in this global checkpoint.
getNextEventOpInEpoch3()	Gets the next event operation in this global checkpoint, showing any received anyvalues. Added in NDB 7.3.20, 7.4.18, 7.5.9, and 7.6.4.
getReference()	Retrieves a reference or identifier for the Ndb object instance.
init()	Initializes an Ndb object and makes it ready for use.
isConsistent()	Whether all received events are consistent. Deprecated in NDB 7.4.3.
isConsistentGCI()	Whether all received events for a given global checkpoint are consistent. Deprecated in NDB 7.4.3.
isExpectingHigherQueuedEpochs()	Check whether there are new queued epochs, or there was a cluster failure event. Added in NDB 7.3.10 and 7.4.7.
nextEvent()	Gets the next event from the queue. Deprecated in NDB 7.4.3.
nextEvent2()	Gets the next event from the queue. Added in NDB 7.4.3.
pollEvents()	Waits for an event to occur. Deprecated in NDB 7.4.3.
pollEvents2()	Waits for an event to occur. Added in NDB 7.4.3.
setDatabaseName()	Sets the name of the current database.
setDatabaseSchemaName()	Sets the name of the current database schema.
setEventBufferQueueEmptyEpoch()	Enables queuing of empty events. Added in NDB 7.4.11 and NDB 7.5.2.
set_eventbuf_max_alloc()	Sets the current allocated maximum size of the event buffer. Added in NDB 7.3.3.
set_eventbuffer_free_percent()	Sets the percentage of event buffer memory that should be available before buffering resumes, once the limit has been reached. Added in NDB 7.4.3.
setNdbObjectName()	For debugging purposes: sets an arbitrary name for this Ndb object. Added in NDB 7.3.6.
startTransaction()	Begins a transaction. (See Section 2.3.30, “The NdbTransaction Class”.)

2.3.16.1 Ndb Class Constructor

Description. This creates an instance of Ndb, which represents a connection to the NDB Cluster. All NDB API applications should begin with the creation of at least one Ndb object. This requires the creation of at least one instance of Ndb_cluster_connection, which serves as a container for a cluster connection string.

Signature.

```
Ndb
    (
      Ndb_cluster_connection* ndb_cluster_connection,
```

```
    const char*                     catalogName = "",
    const char*                     schemaName = "def"
  )
```

Parameters. The `Ndb` class constructor can take up to 3 parameters, of which only the first is required:

- *`ndb_cluster_connection`* is an instance of `Ndb_cluster_connection`, which represents a cluster connection string. (See Section 2.3.17, "The Ndb_cluster_connection Class".)

  Prior to NDB 7.3.8 and NDB 7.4.3, it was possible to delete the `Ndb_cluster_connection` used to create a given instance of `Ndb` without first deleting the dependent `Ndb` object. (Bug #19999242)

- *`catalogName`* is an optional parameter providing a namespace for the tables and indexes created in any connection from the `Ndb` object.

  This is equivalent to what `mysqld` considers "the database".

  The default value for this parameter is an empty string.

- The optional *`schemaName`* provides an additional namespace for the tables and indexes created in a given catalog.

  The default value for this parameter is the string "def".

Return value. An `Ndb` object.

~Ndb() (Class Destructor). The destructor for the `Ndb` class should be called in order to terminate an instance of `Ndb`. It requires no arguments, nor any special handling.

2.3.16.2 Ndb::closeTransaction()

Description. This is one of two NDB API methods provided for closing a transaction (the other being `NdbTransaction::close()`). You must call one of these two methods to close the transaction once it has been completed, whether or not the transaction succeeded.

> **Important**
>
> If the transaction has not yet been committed, it is aborted when this method is called. See Section 2.3.16.35, "Ndb::startTransaction()".

Signature.

```
void closeTransaction
    (
      NdbTransaction *transaction
    )
```

Parameters. This method takes a single argument, a pointer to the `NdbTransaction` to be closed.

Return value. N/A.

2.3.16.3 Ndb::computeHash()

Description. This method can be used to compute a distribution hash value, given a table and its keys.

> **Important**
>
> `computeHash()` can be used only for tables that use native `NDB` partitioning.

Signature.

```
static int computeHash
    (
      Uint32*                      hashvalueptr,
      const NdbDictionary::Table* table,
      const struct Key_part_ptr*  keyData,
      void*                        xfrmbuf = 0,
      Uint32                       xfrmbuflen = 0
    )
```

Parameters. This method takes the following parameters:

- If the method call is successful, *hashvalueptr* is set to the computed hash value.
- A pointer to a *table* (see Section 2.3.37, "The Table Class").
- *keyData* is a null-terminated array of pointers to the key parts that are part of the table's distribution key. The length of each key part is read from metadata and checked against the passed value (see Section 2.3.15, "The Key_part_ptr Structure").
- *xfrmbuf* is a pointer to temporary buffer used to calculate the hash value.
- *xfrmbuflen* is the length of this buffer.

Note

If *xfrmbuf* is `NULL` (the default), then a call to `malloc()` or `free()` is made automatically, as appropriate. `computeHash()` fails if `xfrmbuf` is not `NULL` and *xfrmbuflen* is too small.

Previously, it was assumed that the memory returned by the `malloc()` call would always be suitably aligned, which is not always the case. Beginning with NDB 7.3.2, when `malloc()` provides a buffer to this method, the buffer is explicitly aligned after it is allocated, and before it is actually used. (Bug #16484617)

Return value. 0 on success, an error code on failure. (If the method call succeeds, the computed hash value is made available via *hashvalueptr*.)

2.3.16.4 Ndb::createEventOperation()

Description. This method creates a subscription to a database event.

Note

NDB API event subscriptions do not persist after an NDB Cluster has been restored using `ndb_restore`; in such cases, all of the subscriptions must be recreated explicitly.

Signature.

```
NdbEventOperation* createEventOperation
    (
      const char *eventName
    )
```

Parameters. This method takes a single argument, the unique *eventName* identifying the event to which you wish to subscribe.

Return value. A pointer to an `NdbEventOperation` object (or `NULL`, in the event of failure). See Section 2.3.21, "The NdbEventOperation Class".

2.3.16.5 Ndb::dropEventOperation()

Description. This method drops a subscription to a database event represented by an `NdbEventOperation` object.

Important

Memory used by an event operation which has been dropped is not freed until the event buffer has been completely read. This means you must continue to call `pollEvents()` and `nextEvent()` in such cases until these methods return `0` and `NULL`, respectively in order for this memory to be freed.

Signature.

```
int dropEventOperation
    (
      NdbEventOperation *eventOp
    )
```

Parameters. This method requires a single input parameter, a pointer to an instance of `NdbEventOperation`.

Return value. **0** on success; any other result indicates failure.

2.3.16.6 Ndb::getDictionary()

Description. This method is used to obtain an object for retrieving or manipulating database schema information. This `Dictionary` object contains meta-information about all tables in the cluster.

Note

The dictionary returned by this method operates independently of any transaction. See Section 2.3.4, "The Dictionary Class", for more information.

Signature.

```
NdbDictionary::Dictionary* getDictionary
    (
      void
    ) const
```

Parameters. *None*.

Return value. An instance of the `Dictionary` class.

2.3.16.7 Ndb::getDatabaseName()

Description. This method can be used to obtain the name of the current database.

Signature.

```
const char* getDatabaseName
    (
      void
    )
```

Parameters. None.

Return value. The name of the current database.

2.3.16.8 Ndb::getDatabaseSchemaName()

Description. This method can be used to obtain the current database schema name.

Signature.

```
const char* getDatabaseSchemaName
    (
      void
    )
```

Parameters. None.

Return value. The name of the current database schema.

2.3.16.9 Ndb::getGCIEventOperations()

Description. Iterates over distinct event operations which are part of the current GCI, becoming valid after calling `nextEvent()`. You can use this method to obtain summary information for the epoch (such as a list of all tables) before processing the event data.

This method is deprecated in NDB 7.4.3, and is subject to removal in a future release. In NDB 7.4.3 and later, you should use `getNextEventOpInEpoch2()` instead.

Signature.

```
const NdbEventOperation* getGCIEventOperations
    (
      Uint32* iter,
      Uint32* event_types
    )
```

Parameters. An iterator and a mask of event types. Set `*iter=0` to start.

Return value. The next event operation; returns `NULL` when there are no more event operations. If *`event_types`* is not `NULL`, then after calling the method it contains a bitmask of the event types received. .

2.3.16.10 Ndb::get_eventbuf_max_alloc()

Description. Gets the maximum memory, in bytes, that can be used for the event buffer. This is the same as reading the value of the `ndb_eventbuffer_max_alloc` system variable in the MySQL Server.

This method was added in NDB 7.3.3.

Signature.

```
unsigned get_eventbuf_max_alloc
    (
      void
    )
```

Parameters. *None*.

Return value. The mamximum memory available for the event buffer, in bytes.

2.3.16.11 Ndb::get_eventbuffer_free_percent()

Description. Gets `ndb_eventbuffer_free_percent`—that is, the percentage of event buffer memory that should be available before buffering resumes, once `ndb_eventbuffer_max_alloc` has been reached. This value is calculated as *`used`* `* 100 / ndb_eventbuffer_max_alloc`, where *`used`* is the amount of event buffer memory actually used, in bytes.

This method was added in NDB 7.4.3.

Signature.

```
unsigned get_eventbuffer_free_percent
    (
      void
    )
```

Parameters. The percentage (*pct*) of event buffer memory that must be present. Valid range is 1 to 99 inclusive.

Return value. *None*.

2.3.16.12 Ndb::get_event_buffer_memory_usage()

Description. Gets event buffer usage as a percentage of `ndb_eventbuffer_max_alloc`. Unlike `get_eventbuffer_free_percent()`, this method makes complete usage information available in the form of an `EventBufferMemoryUsage` data structure.

This method was added in NDB 7.4.3.

Signature.

```
void get_event_buffer_memory_usage
    (
      EventBufferMemoryUsage&
    )
```

Parameters. A reference to an `EventBufferMemoryUsage` structure, which receives the usage data.

Return value. *None*.

2.3.16.13 Ndb::getHighestQueuedEpoch()

Description. Added in NDB 7.4.3, this method supersedes `getLatestGCI()`, which is now deprecated and subject to removal in a future NDB Cluster release.

Prior to NDB 7.4.7, this method returned the highest epoch number in the event queue. In NDB 7.4.7 and later, it returns the highest epoch number found after calling `pollEvents2()` (Bug #20700220).

Signature.

```
Uint64 getHighestQueuedEpoch
    (
      void
    )
```

Parameters. *None*.

Return value. The most recent epoch number, an integer.

2.3.16.14 Ndb::getLatestGCI()

Description. Gets the index for the most recent global checkpoint.

This method is deprecated in NDB 7.4.3, and is subject to removal in a future release. In NDB 7.4.3 and later, you should use `getHighestQueuedEpoch()` instead.

Signature.

```
Uint64 getLatestGCI
```

```
    (
      void
    )
```

Parameters. *None*.

Return value. The most recent GCI, an integer.

2.3.16.15 Ndb::getNdbError()

Description. This method provides you with two different ways to obtain an `NdbError` object representing an error condition. For more detailed information about error handling in the NDB API, see NDB Cluster API Errors.

Signature. The `getNdbError()` method actually has two variants.

The first of these simply gets the most recent error to have occurred:

```
const NdbError& getNdbError
    (
      void
    )
```

The second variant returns the error corresponding to a given error code:

```
const NdbError& getNdbError
    (
      int errorCode
    )
```

Regardless of which version of the method is used, the `NdbError` object returned persists until the next NDB API method is invoked.

Parameters. To obtain the most recent error, simply call `getNdbError()` without any parameters. To obtain the error matching a specific *`errorCode`*, invoke the method passing the code (an `int`) to it as a parameter. For a listing of NDB API error codes and corresponding error messages, see Section 2.4, "NDB API Errors and Error Handling".

Return value. An `NdbError` object containing information about the error, including its type and, where applicable, contextual information as to how the error arose. See Section 2.3.20, "The NdbError Structure", for details.

2.3.16.16 Ndb::getNdbErrorDetail()

Description. This method provides an easy and safe way to access any extra information about an error. Rather than reading these extra details from the `NdbError` object's `details` property (now now deprecated in favor of `getNdbErrorDetail()`-see Bug #48851). This method enables storage of such details in a user-supplied buffer, returning a pointer to the beginning of this buffer. In the event that the string containing the details exceeds the length of the buffer, it is truncated to fit.

`getErrorDetail()` provides the source of an error in the form of a string. In the case of a unique constraint violation (error 893), this string supplies the fully qualified name of the index where the problem originated, in the format *`database-name`*/*`schema-name`*/*`table-name`*/*`index-name`*, (`NdbError.details`, on the other hand, supplies only an index ID, and it is often not readily apparent to which table this index belongs.) Regardless of the type of error and details concerning this error, the string retrieved by `getErrorDetail()` is always null-terminated.

Signature. The `getNdbErrorDetail()` method has the following signature:

```
const char* getNdbErrorDetail
            (
```

```
              const NdbError& error,
              char*           buffer,
              Uint32          bufferLength
            ) const
```

Parameters. To obtain detailed information about an error, call `getNdbErrorDetail()` with a reference to the corresponding `NdbError` object, a *`buffer`*, and the length of this buffer (expressed as an unsigned 32-bit integer).

Return value. When extra details about the *`error`* are available, this method returns a pointer to the beginning of the *`buffer`* supplied. As stated previously, if the string containing the details is longer than *`bufferLength`*, the string is truncated to fit. In the event that no addition details are available, `getNdbErrorDetail()` returns `NULL`.

2.3.16.17 Ndb::getNdbObjectName()

Description. If a name was set for the `Ndb` object prior to its initialization, you can retrieve it using this method. Used for debugging.

Signature.

```
const char* getNdbObjectName
    (
      void
    ) const
```

Parameters. *None*.

Return value. The `Ndb` object name, if one has been set using `setNdbObjectName()`. Otherwise, this method returns 0.

This method was added in NDB 7.3.6. (Bug #18419907)

2.3.16.18 Ndb::getNextEventOpInEpoch2()

Description. Iterates over individual event operations making up the current global checkpoint. Use following `nextEvent2()` to obtain summary information for the epoch, such as a listing of all tables, before processing event data.

Note

Exceptional epochs do not have any event operations associated with them.

Signature.

```
const NdbEventOperation* getNextEventOpInEpoch2
    (
      Uint32* iter,
      Uint32* event_types
    )
```

Parameters. Set *`iter`* to 0 initially; this is *`NULL`* when there are no more events within this epoch. If *`event_types`* is not *`NULL`*, it holds a bitmask of the event types received.

Return value. A pointer to the next `NdbEventOperation`, if there is one.

2.3.16.19 Ndb::getNextEventOpInEpoch3()

Description. Iterates over individual event operations making up the current global checkpoint. Use following `nextEvent2()` to obtain summary information for the epoch, such as a listing of all tables, before processing event data. Is the same as `getNextEventOpInEpoch3()` but with the addition of a third argument which holds the merger of all AnyValues received, showing which bits are set for all operations on a given table.

Note

Exceptional epochs do not have any event operations associated with them.

Signature.

```
const NdbEventOperation* getNextEventOpInEpoch2
    (
      Uint32* iter,
      Uint32* event_types
      Uint32* cumulative_any_value
    )
```

Parameters. Set *`iter`* to 0 initially; this is *`NULL`* when there are no more events within this epoch. If *`event_types`* is not *`NULL`*, it holds a bitmask of the event types received. If *`cumulative_any_value`* is not `NULL`, it holds the merger of all AnyValues received.

Return value. A pointer to the next `NdbEventOperation`, if there is one.

This method was added in NDB 7.3.20, 7.4.18, 7.5.9, and 7.6.4. (Bug #26333981)

2.3.16.20 Ndb::getReference()

Description. This method can be used to obtain a reference to a given `Ndb` object. This is the same value that is returned for a given operation corresponding to this object in the output of `DUMP 2350`.

Signature.

```
Uint32 getReference
    (
      void
    )
```

Parameters. *None*.

Return value. A 32-bit unsigned integer.

2.3.16.21 Ndb::init()

Description. This method is used to initialize an `Ndb` object.

Signature.

```
int init
    (
      int maxNoOfTransactions = 4
    )
```

Parameters. The `init()` method takes a single parameter *`maxNoOfTransactions`* of type integer. This parameter specifies the maximum number of parallel `NdbTransaction` objects that can be handled by this instance of `Ndb`. The maximum permitted value for *`maxNoOfTransactions`* is 1024; if not specified, it defaults to 4.

Note

Each scan or index operation uses an extra `NdbTransaction` object.

Return value. This method returns an `int`, which can be either of the following two values:

- **0**: indicates that the `Ndb` object was initialized successfully.
- **-1**: indicates failure.

2.3.16.22 Ndb::isConsistent()

Description. Check if all events are consistent. If a node failure occurs when resources are exhausted, events may be lost and the delivered event data might thus be incomplete. This method makes it possible to determine if this is the case.

This method is deprecated in NDB 7.4.3, and is subject to removal in a future release. In NDB 7.4.3 and later, you should instead use `NdbEventOperation::getEventType2()` to determine the type of event—in this instance, whether the event is of type `TE_INCONSISTENT`. See Section 2.3.6.23, “Event::TableEvent”.

Signature.

```
bool isConsistent
    (
      Uint64& gci
    )
```

Parameters. A reference to a global checkpoint index. This is the first inconsistent GCI found, if any.

Return value. `true` if all events are consistent.

2.3.16.23 Ndb::isConsistentGCI()

Description. If a node failure occurs when resources are exhausted, events may be lost and the delivered event data might thus be incomplete. This method makes it possible to determine if this is the case by checking whether all events in a given GCI are consistent.

This method is deprecated in NDB 7.4.3, and is subject to removal in a future release. In NDB 7.4.3 and later, you should instead use `NdbEventOperation::getEventType2()` to determine the type of event—in this instance, whether the event is of type `TE_INCONSISTENT`. See Section 2.3.6.23, “Event::TableEvent”.

Signature.

```
bool isConsistentGCI
    (
      Uint64 gci
    )
```

Parameters. A global checkpoint index.

Return value. `true` if this GCI is consistent; `false` indicates that the GCI may be possibly inconsistent.

2.3.16.24 Ndb::isExpectingHigherQueuedEpochs()

Description. Check whether higher queued epochs have been seen by the last invocation of `Ndb::pollEvents2()`, or whether a **`TE_CLUSTER_FAILURE`** event was found.

It is possible, after a cluster failure has been detected, for the highest queued epoch returned by `pollEvents2()` not to be increasing any longer. In this case, rather than poll for more events, you should instead consume events with `nextEvent()` until it detects a **`TE_CLUSTER_FAILURE`** is detected, then reconnect to the cluster when it becomes available again.

This method was added in NDB 7.3.10 and 7.4.7 (Bug #18753887).

Signature.

```
bool isExpectingHigherQueuedEpochs
      (
        void
      )
```

Parameters. *None*.

Return value. True if queued epochs were seen by the last `pollEvents2()` call or, in the event of cluster failure.

2.3.16.25 Ndb::nextEvent()

Description. Returns the next event operation having data from a subscription queue.

This method is deprecated in NDB 7.4.3, and is subject to removal in a future release. In NDB 7.4.3 and later, you should use `nextEvent2()` instead.

Signature.

```
NdbEventOperation* nextEvent
    (
      void
    )
```

Parameters. None.

Return value. This method returns an `NdbEventOperation` object representing the next event in a subscription queue, if there is such an event. If there is no event in the queue, it returns `NULL` instead.

Beginning with NDB 7.3.6, this method clears inconsistent data events from the event queue when processing them. In order to able to clear all such events in these and later versions, applications must call this method even in cases when `pollEvents()` has already returned 0. (Bug #18716991)

2.3.16.26 Ndb::nextEvent2()

Description. Returns the event operation associated with the data dequeued from the event queue. This should be called repeatedly after `pollEvents2()` populates the queue, until the event queue is empty.

Added in NDB 7.4.3, this method supersedes `nextEvent()`, which is now deprecated and subject to removal in a future NDB Cluster release.

After calling this method, use `NdbEventOperation::getEpoch()` to determine the epoch, then check the type of the returned event data using `NdbEventOperation::getEventType2()`. Handling must be provided for all exceptional `TableEvent` types, including `TE_EMPTY`, `TE_INCONSISTENT`, and `TE_OUT_OF_MEMORY` (also introduced in NDB 7.4.3). No other `NdbEventOperation` methods than the two named here should be called for an exceptional epoch. Returning empty epochs (`TE_EMPTY`) may flood applications when data nodes are idle. If this is not desirable, applications should filter out any empty epochs.

Signature.

```
NdbEventOperation* nextEvent2
    (
      void
    )
```

Parameters. None.

Return value. This method returns an `NdbEventOperation` object representing the next event in an event queue, if there is such an event. If there is no event in the queue, it returns `NULL` instead.

2.3.16.27 Ndb::pollEvents()

Description. This method waits for a GCP to complete. It is used to determine whether any events are available in the subscription queue.

This method waits for the next *epoch*, rather than the next GCP. See Section 2.3.21, "The NdbEventOperation Class", for more information.

In NDB 7.4.3 and later, you can (and should) use `pollEvents2()` instead of this method.

Prior to NDB 7.4.7, `pollEvents()` was not compatible with the exceptional `TableEvent` types added in NDB 7.4.3 (Bug #20646496); in NDB 7.4.7 and later, `pollEvents()` is compatible with these event types, as described later in this section.

Signature.

```
int pollEvents
    (
      int     maxTimeToWait,
      Uint64* latestGCI = 0
    )
```

Parameters. This method takes the two parameters listed here:

- The maximum time to wait, in milliseconds, before "giving up" and reporting that no events were available (that is, before the method automatically returns `0`).

  A negative value causes the wait to be indefinite and never time out. This is not recommended (and is not supported by the successor method `pollEvents2()`).

- The index of the most recent global checkpoint. Normally, this may safely be permitted to assume its default value, which is `0`.

Return value. `pollEvents()` returns a value of type `int`, which may be interpreted as follows:

- `> 0`: There are events available in the queue.

- `0`: There are no events available.

- In NDB 7.4.7 and later, a negative value indicates failure and **`NDB_FAILURE_GCI`** (`~(Uint64)0`) indicates cluster failure (Bug #18753887); 1 is returned when encountering an exceptional event, except when only `TE_EMPTY` events are found, as described later in this section.

In NDB 7.4.7 and later, when `pollEvents()` finds an exceptional event at the head of the event queue, the method returns 1 and otherwise behaves as follows:

- Empty events (`TE_EMPTY`) are removed from the event queue head until an event containing data is found. When this results in the entire queue being processed without encountering any data, the method returns 0 (no events available) rather than 1. This behavior makes this event type transparent to an application using `pollEvents()`.

- After encountering an event containing inconsistent data (`TE_INCONSISTENT`) due to data node buffer overflow, the next call to `nextEvent()` call removes the inconsistent data event data from the event queue, and returns `NULL`. You should check the inconsistency by calling `isConsistent()` immediately thereafter.

  Important: Although the inconsistent event data is removed from the event queue by calling `nextEvent()`, information about the inconsistency is removed only by another `nextEvent()` call following this, that actually finds an event containing data.

- When `pollEvents()` finds a data buffer overflow event (`TE_OUT_OF_MEMORY`), the event data is added to the event queue whenever event buffer usage exceeds `ndb_eventbuffer_max_alloc`. In this case, the next call to `nextEvent()` exits the process.

2.3.16.28 Ndb::pollEvents2()

Description. Waits for an event to occur. Returns as soon as any event data is available. This method also moves an epoch's complete event data to the event queue.

Added in NDB 7.4.3, this method supersedes `pollEvents()`, which is now deprecated and subject to removal in a future NDB Cluster release.

Signature.

```
int pollEvents2
    (
      int aMillisecondNumber,
      Uint64* highestQueuedEpoch = 0
    )
```

Parameters. This method takes the two parameters listed here:

- The maximum time to wait, in milliseconds, before giving up and reporting that no events were available (that is, before the method automatically returns `0`).

  In NDB 7.4.7 and later, specifying a negative value for this argument causes `pollEvents2()` to return -1, indicating an error (Bug #20762291).

- The index of the highest queued epoch. Normally, this may safely be permitted to assume its default value, which is `0`. If this value is not `NULL` and new event data is available in the event queue, it is set to the highest epoch found in the available event data.

Return value. `pollEvents2()` returns an integer whose value can be interpreted as follows:

- `> 0`: There are events available in the queue.
- `0`: There are no events available.
- `< 0`: Indicates failure (possible error).

2.3.16.29 Ndb::setDatabaseName()

Description. This method is used to set the name of the current database.

Signature.

```
void setDatabaseName
    (
      const char *databaseName
    )
```

Parameters. `setDatabaseName()` takes a single, required parameter, the name of the new database to be set as the current database.

Return value. N/A.

2.3.16.30 Ndb::setDatabaseSchemaName()

Description. This method sets the name of the current database schema.

Signature.

```
void setDatabaseSchemaName
```

```
    (
      const char *databaseSchemaName
    )
```

Parameters. The name of the database schema.

Return value. N/A.

2.3.16.31 Ndb::setEventBufferQueueEmptyEpoch()

Description. Queuing of empty epochs is disabled by default. This method can be used to enable such queuing, in which case any new, empty epochs entering the event buffer following the method call are queued.

When queuing of empty epochs is enabled, `nextEvent()` associates an empty epoch to one and only one of the subscriptions (event operations) connected to the subscribing `Ndb` object. This means that there can be no more than one empty epoch per subscription, even though the user may have many subscriptions associated with the same `Ndb` object.

Signature.

```
void setEventBufferQueueEmptyEpoch
  (
    bool queue_empty_epoch
  )
```

Parameters. This method takes a single input parameter, a boolean. Invoking the method with `true` enables queuing of empty events; passing `false` to the method disables such queuing.

Return value. *None*.

> **Note**
>
> `setEventBufferQueueEmptyEpoch()` has no associated getter method. This is intentional, and is due to the fact this setter applies to queuing *new* epochs, whereas the queue itself may still reflect the state of affairs that existed prior to invoking the setter. Thus, during a transition period, an empty epoch might be found in the queue even if queuing is turned off.

`setEventBufferQueueEmptyEpoch()` was added in NDB 7.4.11 and NDB 7.5.2.

2.3.16.32 Ndb::set_eventbuf_max_alloc()

Description. Sets the maximum memory, in bytes, that can be used for the event buffer. This has the same effect as setting the value of the `ndb_eventbuffer_max_alloc` system variable in the MySQL Server.

This method was added in NDB 7.3.3.

Signature.

```
void set_eventbuf_max_alloc
    (
      unsigned size
    )
```

Parameters. The desired maximum *`size`* for the event buffer, in bytes.

Return value. *None*.

2.3.16.33 Ndb::set_eventbuffer_free_percent()

Description. Sets `ndb_eventbuffer_free_percent`—that is, the percentage of event buffer memory that should be available before buffering resumes, once `ndb_eventbuffer_max_alloc` has been reached.

This method was added in NDB 7.4.3.

Signature.

```
int set_eventbuffer_free_percent
    (
      unsigned pct
    )
```

Parameters. The percentage (*`pct`*) of event buffer memory that must be present. Valid range is 1 to 99 inclusive.

Return value. The value that was set.

2.3.16.34 Ndb::setNdbObjectName()

Description. Starting with NDB 7.3.6, you can set an arbitrary, human-readable name to identify an `Ndb` object for debugging purposes. This name can then be retrieved using `getNdbObjectName()`. (Bug #18419907) This must be done prior to calling `init()` for this object; trying to set a name after initialization fails with an error.

You can set a name only once for a given `Ndb` object; subsequent attempts after the name has already been set fail with an error.

Signature.

```
int setNdbObjectName
    (
      const char* name
    )
```

Parameters. A *`name`* that is intended to be human-readable.

Return value. 0 on success.

2.3.16.35 Ndb::startTransaction()

Description. This method is used to begin a new transaction. There are three variants, the simplest of these using a table and a partition key or partition ID to specify the transaction coordinator (TC). The third variant makes it possible for you to specify the TC by means of a pointer to the data of the key.

> **Important**
>
> When the transaction is completed it must be closed using `NdbTransaction::close()` or `Ndb::closeTransaction()`. Failure to do so aborts the transaction. This must be done regardless of the transaction's final outcome, even if it fails due to an error.
>
> See Section 2.3.16.2, "Ndb::closeTransaction()", and Section 2.3.30.1, "NdbTransaction::close()", for more information.

Signature.

```
NdbTransaction* startTransaction
    (
      const NdbDictionary::Table* table = 0,
      const char* keyData = 0,
      Uint32* keyLen = 0
```

```
    )
```

Parameters. This method takes the following three parameters:

- *`table`*: A pointer to a `Table` object. This is used to determine on which node the transaction coordinator should run.
- *`keyData`*: A pointer to a partition key corresponding to *`table`*.
- *`keyLen`*: The length of the partition key, expressed in bytes.

Distribution-aware forms of startTransaction(). It is also possible to employ *distribution awareness* with this method; that is, to suggest which node should act as the transaction coordinator.

Signature.

```
NdbTransaction* startTransaction
    (
      const NdbDictionary::Table* table,
      const struct Key_part_ptr*  keyData,
      void*                       xfrmbuf = 0,
      Uint32                      xfrmbuflen = 0
    )
```

Parameters. When specifying the transaction coordinator, this method takes the four parameters listed here:

- A pointer to a *`table`* (`Table` object) used for deciding which node should act as the transaction coordinator.
- A null-terminated array of pointers to the values of the distribution key columns. The length of the key part is read from metadata and checked against the passed value.

  A `Key_part_ptr` is defined as shown in Section 2.3.15, "The Key_part_ptr Structure".
- A pointer to a temporary buffer, used to calculate the hash value.
- The length of the buffer.

If *`xfrmbuf`* is `NULL` (the default), then a call to `malloc()` or `free()` is made automatically, as appropriate. `startTransaction()` fails if `xfrmbuf` is not `NULL` and *`xfrmbuflen`* is too small.

Example. Suppose that the table's partition key is a single `BIGINT` column. Then you would declare the distribution key array as shown here:

```
Key_part_ptr distkey[2];
```

The value of the distribution key would be defined as shown here:

```
unsigned long long distkeyValue= 23;
```

The pointer to the distribution key array would be set as follows:

```
distkey[0].ptr= (const void*) &distkeyValue;
```

The length of this pointer would be set accordingly:

```
distkey[0].len= sizeof(distkeyValue);
```

The distribution key array must terminate with a `NULL` element. This is necessary to avoid to having an additional parameter providing the number of columns in the distribution key:

```
distkey[1].ptr= NULL;
distkey[1].len= NULL;
```

Setting the buffer to `NULL` permits `startTransaction()` to allocate and free memory automatically:

```
xfrmbuf= NULL;
xfrmbuflen= 0;
```

Note

You can also specify a buffer to save having to make explicit `malloc()` and `free()` calls, but calculating an appropriate size for this buffer is not a simple matter; if the buffer is not `NULL` but its length is too short, then the startTransaction() call fails. However, if you choose to specify the buffer, 1 MB is usually a sufficient size.

Now, when you start the transaction, you can access the node that contains the desired information directly.

Another distribution-aware version of this method makes it possible for you to specify a table and partition (using the partition ID) as a hint for selecting the transaction coordinator, and is defined as shown here:

```
NdbTransaction* startTransaction
    (
      const NdbDictionary::Table* table,
      Uint32 partitionId
    )
```

In the event that the cluster has the same number of data nodes as it has replicas, specifying the transaction coordinator gains no improvement in performance, since each data node contains the entire database. However, where the number of data nodes is greater than the number of replicas (for example, where `NoOfReplicas` is set equal to 2 in a cluster with 4 data nodes), you should see a marked improvement in performance by using the distribution-aware version of this method.

It is still possible to use this method as before, without specifying the transaction coordinator. In either case, you must still explicitly close the transaction, whether or not the call to `startTransaction()` was successful.

Return value. On success, an `NdbTransaction` object. In the event of failure, `NULL` is returned.

2.3.17 The Ndb_cluster_connection Class

This class represents a connection to a cluster of data nodes.

Parent class. *None*

Child classes. *None*

Description. An NDB application program should begin with the creation of a single `Ndb_cluster_connection` object, and typically makes use of a single `Ndb_cluster_connection`. The application connects to a cluster management server when this object's `connect()` method is called. By using the `wait_until_ready()` method it is possible to wait for the connection to reach one or more data nodes.

Note

An instance of `Ndb_cluster_connection` used to create an `Ndb` object. Prior to NDB 7.3.8 and NDB 7.4.3, it was possible to delete the `Ndb_cluster_connection` used to create a given instance of `Ndb` without first deleting the dependent `Ndb` object. (Bug #19999242)

Application-level partitioning. There is no restriction against instantiating multiple `Ndb_cluster_connection` objects representing connections to different management servers in a single application, nor against using these for creating multiple instances of the Ndb class. Such Ndb_cluster_connection objects (and the Ndb instances based on them) are not required even to connect to the same cluster.

For example, it is entirely possible to perform *application-level partitioning* of data in such a manner that data meeting one set of criteria are “handed off” to one cluster using an Ndb object that makes use of an Ndb_cluster_connection object representing a connection to that cluster, while data not meeting those criteria (or perhaps a different set of criteria) can be sent to a different cluster through a different instance of Ndb that makes use of an Ndb_cluster_connection “pointing” to the second cluster.

It is possible to extend this scenario to develop a single application that accesses an arbitrary number of clusters. However, in doing so, the following conditions and requirements must be kept in mind:

- A cluster management server (ndb_mgmd) can connect to one and only one cluster without being restarted and reconfigured, as it must read the data telling it which data nodes make up the cluster from a configuration file (config.ini).
- An Ndb_cluster_connection object “belongs” to a single management server whose host name or IP address is used in instantiating this object (passed as the *connection_string* argument to its constructor); once the object is created, it cannot be used to initiate a connection to a different management server.

  (See Section 2.3.17.1, “Ndb_cluster_connection Class Constructor”.)
- An Ndb object making use of this connection (Ndb_cluster_connection) cannot be re-used to connect to a different cluster management server (and thus to a different collection of data nodes making up a cluster). Any given instance of Ndb is bound to a specific Ndb_cluster_connection when created, and that Ndb_cluster_connection is in turn bound to a single and unique management server when it is instantiated.

  (See Section 2.3.16.1, “Ndb Class Constructor”.)
- The bindings described above persist for the lifetimes of the Ndb and Ndb_cluster_connection objects in question.

Therefore, it is imperative in designing and implementing any application that accesses multiple clusters in a single session, that a separate set of Ndb_cluster_connection and Ndb objects be instantiated for connecting to each cluster management server, and that no confusion arises as to which of these is used to access which NDB Cluster.

It is also important to keep in mind that no direct “sharing” of data or data nodes between different clusters is possible. A data node can belong to one and only one cluster, and any movement of data between clusters must be accomplished on the application level.

For examples demonstrating how connections to two different clusters can be made and used in a single application, see Section 2.5.2, “NDB API Example Using Synchronous Transactions and Multiple Clusters”, and Section 3.6.2, “MGM API Event Handling with Multiple Clusters”.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.31 Ndb_cluster_connection class methods and descriptions

Name	Description
Ndb_cluster_connection()	Constructor; creates a connection to a cluster of data nodes.
connect()	Connects to a cluster management server.
get_auto_reconnect()	Gets the auto-reconnection setting for API nodes using this Ndb_cluster_connection.

Name	Description
get_latest_error()	Whether or not the most recent attempt to connect succeeded.
get_latest_error_msg()	If the most recent attempt to connect failed, provides the reason.
get_max_adaptive_send_time()	Get timeout before adaptive send forces the sending of all pending signals.
get_num_recv_threads()	Get number of receive threads.
get_next_ndb_object()	Used to iterate through multiple Ndb objects.
get_recv_thread_activation_threshold()	Get activation level for bound receive threads.
get_system_name()	Get the cluster's system name.
lock_ndb_objects()	Disables the creation of new Ndb objects.
set_auto_reconnect()	Enables or disables auto-reconnection of API nodes using this Ndb_cluster_connection.
set_data_node_neighbour()	Sets a neighbor node for for optimal transaction coordinator placement
set_max_adaptive_send_time()	Set timeout to elapse before adaptive send forces the sending of all pending signals.
set_name()	Provides a name for the connection
set_num_recv_threads()	Set number of receive threads to be bound.
set_recv_thread_cpu()	Set one or more CPUs to bind receive threads to.
set_optimized_node_selection()	Used to control node-selection behavior.
set_service_uri()	Set a URI for publication in the ndbinfo.processes table
set_timeout()	Sets a connection timeout
unlock_ndb_objects()	Enables the creation of new Ndb objects.
unset_recv_thread_cpu()	Unset the binding of the receive thread to one or more CPUs.
wait_until_ready()	Waits until a connection with one or more data nodes is successful.

2.3.17.1 Ndb_cluster_connection Class Constructor

Description. This method creates a connection to an NDB Cluster, that is, to a cluster of data nodes. The object returned by this method is required in order to instantiate an Ndb object. Thus, every NDB API application requires the use of an Ndb_cluster_connection.

Ndb_cluster_connection has two constructors. The first of these is shown here:

Signature.

```
Ndb_cluster_connection
    (
      const char* connection_string = 0
    )
```

Parameters. This version of the constructor requires a single *connection_string* parameter, pointing to the location of the management server.

The second constructor takes a node ID in addition to the connection string argument. Its signature and parameters are shown here:

Signature.

```
Ndb_cluster_connection
    (
      const char* connection_string,
```

```
      int force_api_nodeid
    )
```

Parameters. This version of the constructor takes two arguments, a *`connection_string`* and the node ID (*`force_api_nodeid`*) to be used by this API node. This node ID overrides any node ID value set in the *`connection_string`* argument.

Return value. (*Both versions*:) An instance of `Ndb_cluster_connection`.

2.3.17.2 Ndb_cluster_connection::connect()

Description. This method connects to a cluster management server.

Signature.

```
int connect
    (
      int retries = 30,
      int delay   = 1,
      int verbose = 0
    )
```

Parameters. This method takes three parameters, all of which are optional:

- *`retries`* specifies the number of times to retry the connection in the event of failure. The default value is 30.

  `0` means that no additional attempts to connect are made in the event of failure; using a negative value for *`retries`* results in the connection attempt being repeated indefinitely.

- The *`delay`* represents the number of seconds between reconnect attempts; the default is `1` second.

- *`verbose`* indicates whether the method should output a report of its progress, with `1` causing this reporting to be enabled; the default is `0` (reporting disabled).

Return value. This method returns an `int`, which can have one of the following 3 values:

- **0**: The connection attempt was successful.

- **1**: Indicates a recoverable error.

- **-1**: Indicates an unrecoverable error.

2.3.17.3 Ndb_cluster_connection::get_auto_reconnect()

Description. This method retrieves the current `AutoReconnect` setting for a given `Ndb_cluster_connection`. For more detailed information, see Section 2.3.17.12, "Ndb_cluster_connection::set_auto_reconnect()".

Signature.

```
int get_auto_reconnect
    (
      void
    )
```

Parameters. *None*.

Return value. An integer value `0` or `1`, corresponding to the current `AutoReconnect` setting in effect for for this connection. `0` forces API nodes to use new connections to the cluster, while `1` enables API nodes to re-use existing connections.

2.3.17.4 Ndb_cluster_connection::get_latest_error()

Description. This method can be used to determine whether or not the most recent `connect()` attempt made by this `Ndb_cluster_connection` succeeded . If the connection succeeded, `get_latest_error()` returns `0`; otherwise, it returns `1`. If the connection attempt failed, use `Ndb_cluster_connection::get_latest_error_msg()` to obtain an error message giving the reason for the failure.

Signature.

```
int get_latest_error
    (
      void
    ) const
```

Parameters. *None*.

Return value. `1` or `0`. A return value of `1` indicates that the latest attempt to connect failed; if the attempt succeeded, a `0` is returned.

2.3.17.5 Ndb_cluster_connection::get_latest_error_msg()

Description. If the most recent connection attempt by this `Ndb_cluster_connection` failed (as determined by calling `get_latest_error()`), this method provides an error message supplying information about the reason for the failure.

Signature.

```
const char* get_latest_error_msg
    (
      void
    ) const
```

Parameters. *None*.

Return value. A string containing an error message describing a failure by `Ndb_cluster_connection::connect()`. If the most recent connection attempt succeeded, an empty string is returned.

2.3.17.6 Ndb_cluster_connection::get_max_adaptive_send_time()

Description. Get the minimum time in milliseconds that is permit to lapse before the adaptive send mechanism forces all pending signals to be sent.

Signature.

```
Uint32 get_max_adaptive_send_time
    (

    )
```

Parameters. *None*.

Return value. Wait time as a number of milliseconds. This should always be a value between 0 and 10, inclusive.

2.3.17.7 Ndb_cluster_connection::get_next_ndb_object()

Description. This method is used to iterate over a set of `Ndb` objects, retrieving them one at a time.

Signature.

```
const Ndb* get_next_ndb_object
    (
```

```
      const Ndb* p
    )
```

Parameters. This method takes a single parameter, a pointer to the last `Ndb` object to have been retrieved or `NULL`.

Return value. Returns the next `Ndb` object, or `NULL` if no more `Ndb` objects are available.

Iterating over Ndb objects. To retrieve all existing `Ndb` objects, perform the following three steps:

1. Invoke the `lock_ndb_objects()` method. This prevents the creation of any new instances of `Ndb` until the `unlock_ndb_objects()` method is called.

2. Retrieve the first available `Ndb` object by passing `NULL` to `get_next_ndb_object()`. You can retrieve the second `Ndb` object by passing the pointer retrieved by the first call to the next `get_next_ndb_object()` call, and so on. When a pointer to the last available `Ndb` instance is used, the method returns `NULL`.

3. After you have retrieved all desired `Ndb` objects, you should re-enable `Ndb` object creation by calling the `unlock_ndb_objects()` method.

2.3.17.8 Ndb_cluster_connection::get_num_recv_threads()

Description. Get the number of receiver threads.

Signature.

```
int get_num_recv_threads
    (
      void
    ) const
```

Parameters. *None*.

Return value. The number of receiver threads.

2.3.17.9 Ndb_cluster_connection::get_recv_thread_activation_threshold()

Description. Get the level set for activating the receiver thread bound by `set_recv_thread_cpu()`.

Signature.

```
int get_recv_thread_activation_threshold
    (
      void
    ) const
```

Parameters. *None*.

Return value. An integer threshold value. See Section 2.3.17.18, “Ndb_cluster_connection::set_recv_thread_activation_threshold()”, for information about interpreting this value.

2.3.17.10 Ndb_cluster_connection::get_system_name()

Description. Gets the system name from the cluster configuration. This is the value of the `Name` system configuration parameter set in the cluster's `config.ini` configuration file.

Signature.

```
const char* get_system_name
```

```
    (
      void
    ) const
```

Parameters. *None*.

Return value. The cluster system name. If not set in the cluster configuration file, this is a generated value in the form `MC_timestamp` (for example, `MC_20170426182343`), using the time that the management server was started.

2.3.17.11 ndb_cluster_connection::lock_ndb_objects()

Description. Calling this method prevents the creation of new instances of the `Ndb` class. This method must be called prior to iterating over multiple `Ndb` objects using `get_next_ndb_object()`.

Signature.

```
void lock_ndb_objects
    (
      void
    ) const
```

Parameters. *None*.

Return value. *None*.

This method was made `const` in NDB 7.3.15, 7.4.13, and 7.5.4 (Bug #23709232).

For more information, see Section 2.3.17.7, “Ndb_cluster_connection::get_next_ndb_object()”.

2.3.17.12 Ndb_cluster_connection::set_auto_reconnect()

Description. An API node that is disconnected from the cluster is forced to use a new connection object to reconnect, unless this behavior is overridden by setting `AutoReconnect = 1` in the `config.ini` file or calling this method with 1 as the input value. Calling the method with 0 for the value has the same effect as setting the `AutoReconnect` configuration parameter (also introduced in those NDB Cluster versions) to 0; that is, API nodes are forced to create new connections.

Important

When called, this method overrides any setting for `AutoReconnect` made in the `config.ini` file.

For more information, see Defining SQL and Other API Nodes in an NDB Cluster.

Signature.

```
void set_auto_reconnect
    (
      int value
    )
```

Parameters. A `value` of 0 or 1 which determines API node reconnection behavior. 0 forces API nodes to use new connections (`Ndb_cluster_connection` objects); 1 permits API nodes to re-use existing connections to the cluster.

Return value. *None*.

2.3.17.13 Ndb_cluster_connection::set_data_node_neighbour()

Description. Set data node neighbor of the connection, used for optimal placement of the transaction coordinator. This method be used after creating the `Ndb_cluster_connection`, but prior to starting any query threads. This is due to the fact that this method may change the internal state of the `Ndb_cluster_connection` shared by the threads using it. This state is not thread-safe; changing it can lead to non-optimal node selection at the time of the change.

You can use the `ndb_data_node_neighbour` server system variable to set a data node neighbor for an NDB Cluster SQL node.

This method was added in NDB 7.5.2.

Signature.

```
void set_data_node_neighbour
    (
      Uint32 neighbour_node
    )
```

Parameters. The ID of the node to be used as the neighbor.

Return value. *None*.

2.3.17.14 Ndb_cluster_connection::set_max_adaptive_send_time()

Description. Set the minimum time in milliseconds that is permit to lapse before the adaptive send mechanism forces all pending signals to be sent.

Signature.

```
void set_max_adaptive_send_time
    (
      Uint32 milliseconds
    )
```

Parameters. Wait time in milliseconds. The range is 0-10, with 10 being the default value.

Return value. *None*.

2.3.17.15 Ndb_cluster_connection::set_name()

Description. Sets a name for the connection. If the name is specified, it is reported in the cluster log.

Signature.

```
void set_name
    (
      const char* name
    )
```

Parameters. The *`name`* to be used as an identifier for the connection.

Return value. *None*.

2.3.17.16 Ndb_cluster_connection::set_num_recv_threads()

Description. Set the number of receiver threads bound to the CPU (or CPUs) determined using `set_recv_thread_cpu()` and with the threshold set by `set_recv_thread_activation_threshold()`.

This method should be invoked before trying to connect to any other nodes.

Signature.

```
int set_num_recv_threads
    (
      Uint32 num_recv_threads
    )
```

Parameters. The number of receive threads. The only supported value is `1`.

Return value. `-1` indicates an error; any other value indicates success.

2.3.17.17 Ndb_cluster_connection::set_optimized_node_selection()

Description. This method can be used to override the `connect()` method's default behavior as regards which node should be connected to first.

Signature.

```
void set_optimized_node_selection
    (
      int value
    )
```

Parameters. An integer *`value`*.

Return value. *None*.

2.3.17.18 Ndb_cluster_connection::set_recv_thread_activation_threshold()

Description. Set the level for activating the receiver thread bound by `set_recv_thread_cpu()`. Below this level, normal user threads are used to receive signals.

Signature.

```
int set_recv_thread_activation_threshold
    (
      Uint32 threshold
    )
```

Parameters. An integer *`threshold`* value. 16 or higher means that receive threads are never used as receivers. 0 means that the receive thread is always active, and that retains poll rights for its own exclusive use, effectively blocking all user threads from becoming receivers. In such cases care should be taken to ensure that the receive thread does not compete with the user thread for CPU resources; it is preferable for it to be locked to a CPU for its own exclusive use. The default is 8.

Return value. `-1` indicates an error; any other value indicates success.

2.3.17.19 Ndb_cluster_connection::set_service_uri()

Description. Beginning with NDB 7.5.7 and NDB 7.8.2, this method can be used to create a URI for publication in `service_URI` column of the the application's row in the `ndbinfo.processes` table.

Provided that this method is called prior to invoking `connect()`, the service URI is published immediately upon connection; otherwise, it is published after a delay of up to `HeartbeatIntervalDbApi` milliseconds.

Signature.

```
int set_service_uri
    (
      const char* scheme,
      const char* host,
      int port,
      const char* path
```

```
    )
```

Parameters. This method takes the parameters listed here:

- scheme: The URI scheme. This is resticted to lowercase letters, numbers, and the characters `.`, `+`, and `-` (period, plus sign, and dash). The maximu length is 16 characters; any characters over this limit are truncated.

- *`host`*: The URI network address or host name. The maximum length is 48 characters (sufficient for an IPv6 network address); any characters over this limit are truncated. If null, each data node reports the network address from its own connection to this node. An `Ndb_cluster_connection` that uses multiple transporters or network addresses to connect to different data nodes is reflected in multiple rows in the `ndbinfo.processes` table.

- *`port`*: The URI port. This is not published if it is equal to 0.

- *`path`*: The URI path, possibly followed by a query string beginning with `?`. The maximum combined length of the path and query may not exceed 128 characters; if longer, it is truncated to this length.

  The path may not begin with a double slash (`//`).

Return value. 0 on success, 1 in the event of a syntax error.

2.3.17.20 Ndb_cluster_connection::set_recv_thread_cpu()

Description. Set the CPU or CPUs to which the receiver thread should be bound. Set the level for activating the receiver thread as a receiver by invoking `set_recv_thread_activation_threshold()`. Unset the binding for this receiver thread by invoking `unset_recv_thread_cpu()`.

Signature.

```
int set_recv_thread_cpu
    (
      Uint16* cpuid_array,
      Uint32 array_len,
      Uint32 recv_thread_id = 0
    )
```

Parameters. This method takes three parameters, listed here:

- An array of one or more CPU IDs to which the receive thread should be bound
- The length of this array
- The thread ID of the receive thread to bind. The default value is `0`.

Return value. `-1` indicates an error; any other value indicates success.

2.3.17.21 Ndb_cluster_connection::set_timeout()

Description. Used to set a timeout for the connection, to limit the amount of time that we may block when connecting.

This method is actually a wrapper for the function `ndb_mgm_set_timeout()`. For more information, see Section 3.2.4.12, “ndb_mgm_set_timeout()”.

Signature.

```
int set_timeout
    (
      int timeout_ms
```

```
    )
```

Parameters. The length of the timeout, in milliseconds (*timeout_ms*). Currently, only multiples of 1000 are accepted.

Return value. 0 on success; any other value indicates failure.

2.3.17.22 Ndb_cluster_connection::unlock_ndb_objects()

Description. This method undoes the effects of the `lock_ndb_objects()` method, making it possible to create new instances of `Ndb`. `unlock_ndb_objects()` should be called after you have finished retrieving `Ndb` objects using the `get_next_ndb_object()` method.

Signature.

```
void unlock_ndb_objects
    (
      void
    ) const
```

Parameters. *None*.

Return value. *None*.

This method was made `const` in NDB 7.3.15, 7.4.13, and 7.5.4 (Bug #23709232).

For more information, see Section 2.3.17.7, “Ndb_cluster_connection::get_next_ndb_object()”.

2.3.17.23 Ndb_cluster_connection::unset_recv_thread_cpu()

Description. Unset the CPU or CPUs to which the receiver thread was bound using `set_recv_thread_cpu()`.

Signature.

```
int unset_recv_thread_cpu
    (
      Uint32 recv_thread_id
    )
```

Parameters. The thread ID of the receiver thread to be unbound.

Return value. `-1` indicates an error; any other value indicates success.

2.3.17.24 Ndb_cluster_connection::wait_until_ready()

Description. This method is needed to establish connections with the data nodes. It waits until the requested connection with one or more data nodes is successful, or until a timeout condition is met.

Signature.

```
int wait_until_ready
    (
      int timeoutBefore,
      int timeoutAfter
    )
```

Parameters. This method takes two parameters:

- *`timeoutBefore`* determines the number of seconds to wait until the first “live” node is detected. If this amount of time is exceeded with no live nodes detected, then the method immediately returns a negative value.

- *timeoutAfter* determines the number of seconds to wait after the first “live” node is detected for all nodes to become active. If this amount of time is exceeded without all nodes becoming active, then the method immediately returns a value greater than zero.

Return value. `wait_until_ready()` returns an `int`, whose value is interpreted as follows:

- `= 0`: All nodes are “live”.
- `> 0`: At least one node is “live” (however, it is not known whether *all* nodes are “live”).
- `< 0`: An error occurred.

2.3.18 The NdbBlob Class

This class represents a handle to a `BLOB` column and provides read and write access to `BLOB` column values. This object has a number of different states and provides several modes of access to `BLOB` data; these are also described in this section.

Parent class. *None*

Child classes. *None*

Description. This class has no public constructor. An instance of `NdbBlob` is created using the `NdbOperation::getBlobHandle()` method during the operation preparation phase. (See Section 2.3.25, “The NdbOperation Class”.) This object acts as a handle on a `BLOB` column.

BLOB Data Storage. `BLOB` data is stored in 2 locations:

- The header and inline bytes are stored in the blob attribute.
- The blob's data segments are stored in a separate table named `NDB$BLOB_`*`tid`*`_cid`, where *`tid`* is the table ID, and *`cid`* is the blob column ID.

The inline and data segment sizes can be set using the appropriate `Column` methods when the table is created. See Section 2.3.2, “The Column Class”, for more information about these methods.

Data Access Types. `NdbBlob` supports 3 types of data access: These data access types can be applied in combination, provided that they are used in the order given above.

- In the preparation phase, the `NdbBlob` methods `getValue()` and `setValue()` are used to prepare a read or write of a `BLOB` value of known size.
- Also in the preparation phase, `setActiveHook()` is used to define a routine which is invoked as soon as the handle becomes active.
- In the active phase, `readData()` and `writeData()` are used to read and write `BLOB` values having arbitrary sizes.

BLOB Operations. `BLOB` operations take effect when the next transaction is executed. In some cases, `NdbBlob` is forced to perform implicit execution. To avoid this, you should always operate on complete blob data segments.

Use `NdbTransaction::executePendingBlobOps()` to flush reads and writes, which avoids any execution penalty if no operations are pending. This is not necessary following execution of operations, or after the next scan result.

`NdbBlob` also supports reading post- or pre-blob data from events. The handle can be read after the next event on the main table has been retrieved. The data becomes available immediately. (See Section 2.3.21, “The NdbEventOperation Class”, for more information.)

BLOBs and NdbOperations. `NdbOperation` methods acting on `NdbBlob` objects have the following characteristics:.

- `NdbOperation::insertTuple()` must use `NdbBlob::setValue()` if the `BLOB` attribute is nonnullable.
- `NdbOperation::readTuple()` used with any lock mode can read but not write blob values.

  When the `LM_CommittedRead` lock mode is used with `readTuple()`, the lock mode is automatically upgraded to `LM_Read` whenever blob attributes are accessed.
- `NdbOperation::updateTuple()` can either overwrite an existing value using `NdbBlob::setValue()`, or update it during the active phase.
- `NdbOperation::writeTuple()` always overwrites blob values, and must use `NdbBlob::setValue()` if the `BLOB` attribute is nonnullable.
- `NdbOperation::deleteTuple()` creates implicit, nonaccessible `BLOB` handles.
- A scan with any lock mode can use its blob handles to read blob values but not write them.

  A scan using the `LM_Exclusive` lock mode can update row and blob values using `updateCurrentTuple()`; the operation returned must explicitly create its own blob handle.

  A scan using the `LM_Exclusive` lock mode can delete row values (and therefore blob values) using `deleteCurrentTuple()`; this create implicit nonaccessible blob handles.
- An operation which is returned by `lockCurrentTuple()` cannot update blob values.

Known Issues. The following are known issues or limitations encountered when working with `NdbBlob` objects:

- Too many pending `BLOB` operations can overflow the I/O buffers.
- The table and its `BLOB` data segment tables are not created atomically.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.32 NdbBlob class methods and descrptions

Name	Description
`blobsFirstBlob()`	Gets the first blob in a list.
`blobsNextBlob()`	Gets the next blob in a list
`close()`	Release internal resources prior to commit or abort
`getBlobEventName()`	Gets a blob event name
`getBlobTableName()`	Gets a blob data segment's table name.
`getColumn()`	Gets a blob column.
`getLength()`	Gets the length of a blob, in bytes
`getNdbError()`	Gets an error (an `NdbError` object)
`getNdbOperation()`	Get a pointer to the operation (`NdbOperation` object) to which this `NdbBlob` object belonged when created.
`getNull()`	Checks whether a blob value is `NULL`
`getPos()`	Gets the current position for reading/writing
`getState()`	Gets the state of an `NdbBlob` object
`getValue()`	Prepares to read a blob value
`getVersion()`	Checks whether a blob is statement-based or event-based
`readData()`	Reads data from a blob

Name	Description
`setActiveHook()`	Defines a callback for blob handle activation
`setNull()`	Sets a blob to `NULL`
`setPos()`	Sets the position at which to begin reading/writing
`setValue()`	Prepares to insert or update a blob value
`truncate()`	Truncates a blob to a given length
`writeData()`	Writes blob data

Note

`getBlobTableName()` and `getBlobEventName()` are static methods.

Tip

Most `NdbBlob` methods (nearly all of those whose return type is `int`) return `0` on success and `-1` in the event of failure.

Types. The public types defined by `NdbBlob` are shown here:

Table 2.33 NdbBlob types and descriptions

Name	Description
`ActiveHook()`	Callback for `NdbBlob::setActiveHook()`
`State()`	Represents the states that may be assumed by the `NdbBlob`.

2.3.18.1 NdbBlob::ActiveHook

ActiveHook is a data type defined for use as a callback for the `setActiveHook()` method. (See Section 2.3.18.17, “NdbBlob::setActiveHook()”.)

Definition. `ActiveHook` is a custom data type defined as shown here:

```
typedef int ActiveHook
    (
      NdbBlob* me,
      void*    arg
    )
```

Description. This is a callback for `NdbBlob::setActiveHook()`, and is invoked immediately once the prepared operation has been executed (but not committed). Any calls to `getValue()` or `setValue()` are performed first. The `BLOB` handle is active so `readData()` or `writeData()` can be used to manipulate the `BLOB` value. A user-defined argument is passed along with the `NdbBlob`. `setActiveHook()` returns a nonzero value in the event of an error.

2.3.18.2 NdbBlob::blobsFirstBlob()

Description. This method initialises a list of blobs belonging to the current operation and returns the first blob in the list.

Signature.

```
NdbBlob* blobsFirstBlob
    (
      void
    )
```

Parameters. None.

Return value. A pointer to the desired blob.

2.3.18.3 NdbBlob::blobsNextBlob()

Description. Use the method to obtain the next in a list of blobs that was initialised using `blobsFirstBlob()`. See Section 2.3.18.2, “NdbBlob::blobsFirstBlob()”.

Signature.

```
NdbBlob* blobsNextBlob
    (
      void
    )
```

Parameters. None.

Return value. A pointer to the desired blob.

2.3.18.4 NdbBlob::close()

Description. Closes the blob handle, releasing internal resources as it does so, prior to committing or aborting the transaction. In other words, this signals that an application has finished with reading from a given blob. This method can be called only when the blob's `State` is `Active`.

Read operations and locking. When a blob handle is created on a read operation using `LM_Read` or `LM_Exclusive` as the `LockMode`, the read operation can be unlocked only once all Blob handles created on this operation have been closed.

When a row containing blobs has been read with lock mode `LM_CommittedRead`, the mode is automatically upgraded to `LM_Read` to ensure consistency. In this case, when all the blob handles for the row have been closed, an unlock operation for the row is automatically performed by the call to the `close()` method, which adds a pending write operation to the blob. The upgraded lock is released following the call to `execute()`.

Signature.

```
int close
    (
      bool execPendingBlobOps = true
    )
```

Parameters. This method has a single boolean parameter *`execPendingBlobOps`*. If the value of this parameter `true` (the default), any pending blob operations are flushed before the blob handle is closed. If *`execPendingBlobOps`* is `false`, then it is assumed that the blob handle has no pending read or write operations to flush.

Return value. 0 on success.

2.3.18.5 NdbBlob::getBlobEventName()

Description. This method gets a blob event name. The blob event is created if the main event monitors the blob column. The name includes the main event name.

Signature.

```
static int getBlobEventName
    (
      char*       name,
      Ndb*        ndb,
      const char* event,
      const char* column
```

```
    )
```

Parameters. This method takes the four parameters listed here:

- *name*: The name of the blob event.
- *ndb*: The relevant Ndb object.
- *event*: The name of the main event.
- *column*: The blob column.

Return value. 0 on success, -1 on failure.

2.3.18.6 NdbBlob::getBlobTableName()

Description. This method gets the blob data segment table name.

Note

This method is generally of use only for testing and debugging purposes.

Signature.

```
static int getBlobTableName
    (
      char*        name,
      Ndb*         ndb,
      const char* table,
      const char* column
    )
```

Parameters. This method takes the four parameters listed here:

- *name*: The name of the blob data segment table.
- *ndb*: The relevant Ndb object.
- *table*: The name of the main table.
- *column*: The blob column.

Return value. Returns 0 on success, -1 on failure.

2.3.18.7 NdbBlob::getColumn()

Description. Use this method to get the BLOB column to which the NdbBlob belongs.

Signature.

```
const Column* getColumn
    (
      void
    )
```

Parameters. None.

Return value. A Column object. (See Section 2.3.2, "The Column Class".)

2.3.18.8 NdbBlob::getLength()

Description. This method gets the blob's current length in bytes.

Signature.

```
int getLength
    (
      Uint64& length
    )
```

Parameters. A reference to the length.

Return value. The blob's length in bytes. For a `NULL` blob, this method returns `0`. to distinguish between a blob whose length is `0` blob and one which is `NULL`, use the `getNull()` method.

2.3.18.9 NdbBlob::getNull()

Description. This method checks whether the blob's value is `NULL`.

Signature.

```
int getNull
    (
      int& isNull
    )
```

Parameters. A reference to an integer *`isNull`*. Following invocation, this parameter has one of the following values, interpreted as shown here:

- `-1`: The blob is undefined. If this is a nonevent blob, this result causes a state error.
- `0`: The blob has a nonnull value.
- `1`: The blob's value is `NULL`.

Return value. *None*.

2.3.18.10 NdbBlob::getNdbError()

Description. Use this method to obtain an error object. The error may be blob-specific or may be copied from a failed implicit operation. The error code is copied back to the operation unless the operation already has a nonzero error code.

Signature.

```
const NdbError& getNdbError
    (
      void
    ) const
```

Parameters. None.

Return value. An `NdbError` object. See Section 2.3.20, “The NdbError Structure”.

2.3.18.11 NdbBlob::getNdbOperation()

Description. This method can be used to find the operation with which the handle for this `NdbBlob` is associated.

Signature.

```
const NdbOperation* getNdbOperation
    (
      void
    ) const
```

Parameters. *None*.

Return value. A pointer to an operation.

Important

The operation referenced by the pointer returned by this method may be represented by either an `NdbOperation` or `NdbScanOperation` object.

See Section 2.3.25, “The NdbOperation Class”, and Section 2.3.29, “The NdbScanOperation Class”, for more information.

2.3.18.12 NdbBlob::getPos()

Description. This method gets the current read/write position in a blob.

Signature.

```
int getPos
    (
      Uint64& pos
    )
```

Parameters. One parameter, a reference to the position.

Return value. Returns `0` on success, or `-1` on failure. (Following a successful invocation, *`pos`* will hold the current read/write position within the blob, as a number of bytes from the beginning.)

2.3.18.13 NdbBlob::getState()

Description. This method gets the current state of the `NdbBlob` object for which it is invoked. Possible states are described in Section 2.3.18.21, “NdbBlob::State”.

Signature.

```
State getState
    (
      void
    )
```

Parameters. None.

Return value. A `State` value. For possible values, see Section 2.3.18.21, “NdbBlob::State”.

2.3.18.14 NdbBlob::getValue()

Description. Use this method to prepare to read a blob value; the value is available following invocation. Use `getNull()` to check for a `NULL` value; use `getLength()` to get the actual length of the blob, and to check for truncation. `getValue()` sets the current read/write position to the point following the end of the data which was read.

Signature.

```
int getValue
    (
      void*  data,
      Uint32 bytes
    )
```

Parameters. This method takes two parameters. The first of these is a pointer to the *`data`* to be read; the second is the number of *`bytes`* to be read.

Return value. `0` on success, `-1` on failure.

2.3.18.15 NdbBlob::getVersion()

Description. This method is used to distinguish whether a blob operation is statement-based or event-based.

Signature.

```
void getVersion
    (
      int& version
    )
```

Parameters. This method takes a single parameter, an integer reference to the blob version (operation type).

Return value. One of the following three values:

- `-1`: This is a “normal” (statement-based) blob.
- `0`: This is an event-operation based blob, following a change in its data.
- `1`: This is an event-operation based blob, prior to any change in its data.

> **Note**
>
> `getVersion()` is always successful, assuming that it is invoked as a method of a valid `NdbBlob` instance.

2.3.18.16 NdbBlob::readData()

Description. This method is used to read data from a blob.

Signature.

```
int readData
    (
      void*     data,
      Uint32&   bytes
    )
```

Parameters. `readData()` accepts a pointer to the *`data`* to be read, and a reference to the number of *`bytes`* read.

Return value. Returns `0` on success, `-1` on failure. Following a successful invocation, *`data`* points to the data that was read, and *`bytes`* holds the number of bytes read.

2.3.18.17 NdbBlob::setActiveHook()

Description. This method defines a callback for blob handle activation. The queue of prepared operations will be executed in no-commit mode up to this point; then, the callback is invoked. For additional information, see Section 2.3.18.1, “NdbBlob::ActiveHook”.

Signature.

```
int setActiveHook
    (
      ActiveHook*   activeHook,
      void*         arg
    )
```

Parameters. This method requires the two parameters listed here:

- A pointer to an `ActiveHook` value; this is a callback as explained in Section 2.3.18.1, "NdbBlob::ActiveHook".
- A pointer to `void`, for any data to be passed to the callback.

Return value. `0` on success, `-1` on failure.

2.3.18.18 NdbBlob::setNull()

Description. This method sets the value of a blob to `NULL`.

Signature.

```
int setNull
    (
      void
    )
```

Parameters. None.

Return value. `0` on success; `-1` on failure.

2.3.18.19 NdbBlob::setPos()

Description. This method sets the position within the blob at which to read or write data.

Signature.

```
int setPos
    (
      Uint64 pos
    )
```

Parameters. The setPos() method takes a single parameter *`pos`* (an unsigned 64-bit integer), which is the position for reading or writing data. The value of *`pos`* must be between `0` and the blob's current length.

Important

"Sparse" blobs are not supported in the NDB API; in other words, there can be no unused data positions within a blob.

Return value. `0` on success, `-1` on failure.

2.3.18.20 NdbBlob::setValue()

Description. This method is used to prepare for inserting or updating a blob value. Any existing blob data that is longer than the new data is truncated. The data buffer must remain valid until the operation has been executed. `setValue()` sets the current read/write position to the point following the end of the data. You can set *`data`* to a null pointer (`0`) in order to create a `NULL` value.

Signature.

```
int setValue
    (
      const void*  data,
      Uint32       bytes
    )
```

Parameters. This method takes the two parameters listed here:

- The *`data`* that is to be inserted or used to overwrite the blob value.

- The number of *bytes*—that is, the length—of the *data*.

Return value. 0 on success, -1 on failure.

2.3.18.21 NdbBlob::State

This is an enumerated data type which represents the possible states of an NdbBlob instance.

Description. An NdbBlob may assume any one of these states

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.34 NdbBlob::State type values and descriptions

Name	Description
Idle	The NdbBlob has not yet been prepared for use with any operations.
Prepared	This is the state of the NdbBlob prior to operation execution.
Active	This is the BLOB handle's state following execution or the fetching of the next result, but before the transaction is committed.
Closed	This state occurs after the transaction has been committed.
Invalid	This follows a rollback or the close of a transaction.

2.3.18.22 NdbBlob::truncate()

Description. This method is used to truncate a blob to a given length.

Signature.

```
int truncate
    (
      Uint64 length = 0
    )
```

Parameters. truncate() takes a single parameter which specifies the new *length* to which the blob is to be truncated. This method has no effect if *length* is greater than the blob's current length (which you can check using getLength()).

Return value. 0 on success, -1 on failure.

2.3.18.23 NdbBlob::writeData()

Description. This method is used to write data to an NdbBlob. After a successful invocation, the read/write position will be at the first byte following the data that was written to the blob.

Note

A write past the current end of the blob data extends the blob automatically.

Signature.

```
int writeData
    (
      const void*   data,
      Uint32        bytes
    )
```

Parameters. This method takes two parameters, a pointer to the *data* to be written, and the number of *bytes* to write.

Return value. 0 on success, -1 on failure.

2.3.19 The NdbDictionary Class

This class provides meta-information about database objects, such as tables, columns, and indexes.

While the preferred method of database object creation and deletion is through the MySQL Server, NdbDictionary also permits the developer to perform these tasks through the NDB API.

Parent class. *None*

Child classes. Dictionary, Column, Object

Description. This is a data dictionary class that supports enquiries about tables, columns, and indexes. It also provides ways to define these database objects and to remove them. Both sorts of functionality are supplied using inner classes that model these objects. These include the following inner classes:

- Table for working with tables
- Column for creating table columns
- Index for working with secondary indexes
- Dictionary for creating database objects and making schema enquiries
- Event for working with events in the cluster.

Additional Object subclasses model the tablespaces, logfile groups, datafiles, and undofiles required for working with NDB Cluster Disk Data tables (introduced in MySQL 5.1), as well as foreign keys (NDB Cluster 7.3 and later).

Warning

Tables and indexes created using NdbDictionary cannot be viewed from the MySQL Server.

Dropping indexes through the NDB API that were created originally from an NDB Cluster causes inconsistencies. It is possible that a table from which one or more indexes have been dropped using the NDB API will no longer be usable by MySQL following such operations. In this event, the table must be dropped, and then re-created using MySQL to make it accessible to MySQL once more.

Methods. NdbDictionary itself has no public instance methods, only static methods that are used for working with NdbRecord objects. Operations not using NdbRecord are accomplished by means of NdbDictionary subclass instance methods. The following table lists the public methods of NdbDictionary and the purpose or use of each method:

Table 2.35 NdbDictionary class methods and descriptions

Name	Description
getEmptyBitmask()	Returns an empty column presence bitmask which can be used with NdbRecord
getFirstAttrId()	Get the first attribute ID specified by a given NdbRecord object
getRecordIndexName()	Gets the name of the index object referred to by an NdbRecord
getRecordRowLength()	Get the number of bytes needed to store one row of data using a given NdbRecord
getRecordTableName()	Gets the name of the table object referred to by an NdbRecord

Name	Description
`getRecordType()`	Gets the RecordType of an NdbRecord
`getValuePtr()`	Returns a pointer to the beginning of stored data specified by attribute ID, using `NdbRecord`
`isNull()`	Show whether the null bit for a column is true or false
`setNull()`	Set a column's null bit

Note

For the numeric equivalents to enumerations of `NdbDictionary` subclasses, see the file `/storage/ndb/include/ndbapi/NdbDictionary.hpp` in the NDB Cluster source tree.

2.3.19.1 NdbDictionary::getEmptyBitmask()

Description. Returns an empty column presence bitmask which can be used with any `NdbRecord` to specify that no `NdbRecord` columns are to be included in the operation.

Signature.

```
static const unsigned char* getEmptyBitmask
    (
      void
    )
```

Parameters. *None*.

Return value. An empty bitmask.

2.3.19.2 NdbDictionary::getFirstAttrId()

Description. Get the first attribute ID specified by an `NdbRecord` object. Returns `false` if no attribute ID is specified.

Signature.

```
static bool getFirstAttrId
    (
      const NdbRecord* record,
      Uint32& firstAttrId
    )
```

Parameters. A pointer to an `NdbRecord` and a reference to the attribute (*`firstAttrID`*).

Return value. Boolean `false`, when no attribute ID can be obtained.

2.3.19.3 NdbDictionary::getNextAttrId()

Description. Get the next attribute ID specified by an `NdbRecord` object following the attribute ID passed in. Returns `false` when there are no more attribute IDs to be returned.

Signature.

```
static bool getNextAttrId
    (
      const NdbRecord* record,
      Uint32& attrId
    )
```

Parameters. A pointer to an `NdbRecord` and a reference to an attribute ID.

Return value. Boolean `false`, when no attribute ID can be obtained.

2.3.19.4 NdbDictionary::getNullBitOffset()

Description. Get the offset of the given attribute ID's null bit from the start of the `NdbRecord` row. Returns `false` if the attribute ID is not present.

Signature.

```
static bool getNullBitOffset
    (
      const NdbRecord* record,
      Uint32 attrId,
      Uint32& bytes,
      Uint32& bit
    )
```

Parameters. An `NdbRecord` *`record`* in which to get the null bit offset of the given attribute ID (*`attrId`*). The offset is expressed as a number of bytes (*`bytes`*) plus a number of bits within the last byte (*`bit`*).

Return value. Boolean `false`, if the attribute with the given ID is not present.

2.3.19.5 NdbDictionary::getOffset()

Description. Get the offset of the given attribute ID's storage from the start of the `NdbRecord` row. Returns `false` if the attribute id is not present

Signature.

```
static bool getOffset
    (
      const NdbRecord* record,
      Uint32 attrId,
      Uint32& offset
    )
```

Parameters. The *`offset`* of the given attribute ID's storage from the start of the `NdbRecord` row.

Return value. Boolean `false`, if no attribute ID can be found.

2.3.19.6 NdbDictionary::getRecordIndexName()

Description. Get the name of the `Index` object that the `NdbRecord` refers to.

If the `NdbRecord` object is not an `IndexAccess` `NdbRecord`, the method returns null.

Signature.

```
static const char* getRecordIndexName
    (
      const NdbRecord* record
    )
```

Parameters. A pointer to the `NdbRecord` for which to get the name.

Return value. The name, if any. Otherwise, or if the `NdbRecord` object is not of the `IndexAccess` type, this method returns null.

2.3.19.7 NdbDictionary::getRecordRowLength()

Description. Get the number of bytes needed to store one row of data laid out as described by the `NdbRecord` structure passed in to this method.

Signature.

```
static Uint32 getRecordRowLength
    (
      const NdbRecord* record
    )
```

Parameters. An `NdbRecord` object.

Return value. The number of bytes needed per row.

2.3.19.8 NdbDictionary::getRecordTableName()

Description. Return the name of the table object that the `NdbRecord` refers to. This method returns null if the record is not a `TableAccess`.

Signature.

```
static const char* getRecordTableName
    (
      const NdbRecord* record
    )
```

Parameters. The *`record`* (`NdbRecord` object) for which to get the table name.

Return value. The name of the table, or null if the `NdbRecord` object' type is not `TableAccess`.

2.3.19.9 NdbDictionary::getRecordType()

Description. Return the type of the `NdbRecord` object passed.

Signature.

```
static RecordType getRecordType
    (
      const NdbRecord* record
    )
```

Parameters. An `NdbRecord` object.

Return value. The `RecordType` of the `NdbRecord` (`IndexAccess` or `TableAccess`).

2.3.19.10 NdbDictionary::getValuePtr()

Description. Returns a pointer to the beginning of stored data specified by attribute ID, by looking up the offset of the column stored in the NdbRecord object and returning the sum of the row position and the offset.

Note

This method provides both row-const and non-row-const versions.

Signature.

```
static const char* getValuePtr
    (
      const NdbRecord* record,
      const char* row,
      Uint32 attrId
    )
```

```
static char* getValuePtr
    (
      const NdbRecord* record,
      char* row,
      Uint32 attrId
    )
```

Parameters. A pointer to an `NdbRecord` object describing the row format, a pointer to the start of the row data (`const` in the const version of this method), and the attribute ID of the column,

Return value. A pointer to the start of the attribute in the row. This is null if the attribute is not part of the NdbRecord definition.

2.3.19.11 NdbDictionary::isNull()

Description. Indicate whether the null bit for the given column is set to `true` or `false`. The location of the null bit in relation to the row pointer is obtained from the passed `NdbRecord` object. If the column is not nullable, or if the column is not part of the `NdbRecord` definition, the method returns `false`.

Signature.

```
static bool isNull
    (
      const NdbRecord* record,
      const char* row,
      Uint32 attrId
    )
```

Parameters. A pointer to an `NdbRecord` object describing the row format, a pointer to the start of the row data, and the attribute ID of the column to check.

Return value. Boolean `true` if the attribute ID exists in this `NdbRecord`, is nullable, and this row's null bit is set; otherwise, Boolean `false`.

2.3.19.12 NdbDictionary::setNull()

Description. Set the null bit for the given column to the supplied value. The offset for the null bit is obtained from the passed `NdbRecord` object. If the attribute ID is not part of the `NdbRecord`, or if it is not nullable, this method returns an error (-1).

Signature.

```
static int setNull
    (
      const NdbRecord* record,
      char* row,
      Uint32 attrId,
      bool value
    )
```

Parameters. A pointer to the *`record`* (`NdbRecord` object) describing the row format; a pointer to the start of the *`row`* data; the attribute ID of the column (*`attrId`*); and the *`value`* to set the null bit to (`true` or `false`).

Return value. Returns 0 on success; returns -1 if the *`attrId`* is not part of the *`record`*, or is not nullable.

2.3.20 The NdbError Structure

This section discusses the `NdbError` data structure, which contains status and other information about errors, including error codes, classifications, and messages.

Description. An `NdbError` consists of six parts, listed here, of which one is deprecated:

1. *Error status*: This describes the impact of an error on the application, and reflects what the application should do when the error is encountered.

   The error status is described by a value of the `Status` type. See Section 2.3.20.2, "NdbError::Status", for possible `Status` values and how they should be interpreted.

2. *Error classification*: This represents a logical error type or grouping.

   The error classification is described by a value of the `Classification` type. See Section 2.3.20.1, "NdbError::Classification", for possible classifications and their interpretation. Additional information is provided in Section 2.4.4, "NDB Error Classifications".

3. *Error code*: This is an NDB API internal error code which uniquely identifies the error.

   Important

   It is *not* recommended to write application programs which are dependent on specific error codes. Instead, applications should check error status and classification. More information about errors can also be obtained by checking error messages and (when available) error detail messages. However—like error codes—these error messages and error detail messages are subject to change.

   A listing of current error codes, broken down by classification, is provided in Section 2.4.2, "NDB Error Codes: by Type". This listing is updated with new NDB Cluster releases. You can also check the file `storage/ndb/src/ndbapi/ndberror.c` in the NDB Cluster sources.

4. *MySQL Error code*: This is the corresponding MySQL Server error code. MySQL error codes are not discussed in this document; please see Server Error Message Reference, in the MySQL Manual, for information about these.

5. *Error message*: This is a generic, context-independent description of the error.

6. *Error details*: This can often provide additional information (not found in the error message) about an error, specific to the circumstances under which the error is encountered. However, it is not available in all cases.

   Where not specified, the error detail message is `NULL`.

   Note

   This property is deprecated and scheduled for eventual removal. For obtaining error details, you should use the `Ndb::getNdbErrorDetail()` method instead.

Important

Specific NDB API error codes, messages, and detail messages are subject to change without notice.

Definition. The NdbError structure contains the following members, whose types are as shown here:

- `Status status`: The error status.
- `Classification classification`: The error type (classification).
- `int code`: The NDB API error code.
- `int mysql_code`: The MySQL error code.

- `const char* message`: The error message.
- `char* details`: The error detail message.

Note

`details` is deprecated and scheduled for eventual removal. You should use the `Ndb::getNdbErrorDetail()` method instead. (Bug #48851)

See the *Description* for more information about these members and their types.

Types. `NdbError` defines the two data types listed here:

- `Classification`: The type of error or the logical grouping to which the error belongs.
- `Status`: The error status.

2.3.20.1 NdbError::Classification

Description. This type describes the type of error, or the logical group to which it belongs.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.36 NdbError Classification data type values and descriptions

Name	Description
`NoError`	Indicates success (no error occurred)
`ApplicationError`	An error occurred in an application program
`NoDataFound`	A read operation failed due to one or more missing records.
`ConstraintViolation`	A constraint violation occurred, such as attempting to insert a tuple having a primary key value already in use in the target table.
`SchemaError`	An error took place when trying to create or use a table.
`InsufficientSpace`	There was insufficient memory for data or indexes.
`TemporaryResourceError`	This type of error is typically encountered when there are too many active transactions.
`NodeRecoveryError`	This is a temporary failure which was likely caused by a node recovery in progress, some examples being when information sent between an application and `NDB` is lost, or when there is a distribution change.
`OverloadError`	This type of error is often caused when there is insufficient logfile space.
`TimeoutExpired`	A timeout, often caused by a deadlock.
`UnknownResultError`	It is not known whether a transaction was committed.
`InternalError`	A serious error has occurred in `NDB` itself.
`FunctionNotImplemented`	The application attempted to use a function which is not yet implemented.
`UnknownErrorCode`	This is seen where the `NDB` error handler cannot determine the correct error code to report.
`NodeShutdown`	This is caused by a node shutdown.
`SchemaObjectExists`	The application attempted to create a schema object that already exists.
`InternalTemporary`	A request was sent to a node other than the master.

Note

Related information specific to certain error conditions may be found in Section 2.4.2, “NDB Error Codes: by Type”, and in Section 2.4.4, “NDB Error Classifications”.

2.3.20.2 NdbError::Status

Description. This type is used to describe an error's status.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.37 NdbError Status data type values and descriptions

Name	Description
`Success`	No error has occurred
`TemporaryError`	A temporary and usually recoverable error; the application should retry the operation giving rise to the error
`PermanentError`	Permanent error; not recoverable
`UnknownResult`	The operation's result or status is unknown

Note

Related information specific to certain error conditions may be found in Section 2.4.4, “NDB Error Classifications”.

2.3.21 The NdbEventOperation Class

This section describes the `NdbEventOperation` class, which is used to monitor changes (events) in a database. It provides the core functionality used to implement NDB Cluster Replication.

Parent class. *None*

Child classes. *None*

Description. `NdbEventOperation` represents a database event.

Creating an Instance of NdbEventOperation. This class has no public constructor or destructor. Instead, instances of `NdbEventOperation` are created as the result of method calls on `Ndb` and `NdbDictionary` objects, subject to the following conditions:

1. There must exist an event which was created using `Dictionary::createEvent()`. This method returns an instance of the `Event` class.

2. An `NdbEventOperation` object is instantiated using `Ndb::createEventOperation()`, which acts on an instance of `Event`.

An instance of this class is removed by invoking `Ndb::dropEventOperation`.

Tip

A detailed example demonstrating creation and removal of event operations is provided in Section 2.5.8, “NDB API Event Handling Example”.

Known Issues. The following issues may be encountered when working with event operations in the NDB API:

- The maximum number of active `NdbEventOperation` objects is currently fixed at compile time at 2 * `MaxNoOfTables`.

- Currently, all `INSERT`, `DELETE`, and `UPDATE` events—as well as all attribute changes—are sent to the API, even if only some attributes have been specified. However, these are hidden from the user and only relevant data is shown after calling `Ndb::nextEvent()`.

  Note that false exits from `Ndb::pollEvents()` may occur, and thus the following `nextEvent()` call returns zero, since there was no available data. In such cases, simply call `pollEvents()` again.

  See Section 2.3.16.27, “Ndb::pollEvents()”, and Section 2.3.16.25, “Ndb::nextEvent()”.

- Event code does *not* check the table schema version. When a table is dropped, make sure that you drop any associated events.

- If you have received a complete epoch, events from this epoch are not re-sent, even in the event of a node failure. However, if a node failure has occurred, subsequent epochs may contain duplicate events, which can be identified by duplicated primary keys.

  In the NDB Cluster replication code, duplicate primary keys on `INSERT` operations are normally handled by treating such inserts as `REPLACE` operations.

Tip

To view the contents of the system table containing created events, you can use the `ndb_select_all` utility as shown here:

```
ndb_select_all -d sys 'NDB$EVENTS_0'
```

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.38 NdbEventOperation class methods and descriptions

Name	Description
`clearError()`	Clears the most recent error. Deprecated in NDB 7.4.3.
`execute()`	Activates the `NdbEventOperation`
`getBlobHandle()`	Gets a handle for reading blob attributes
`getEpoch()`	Retrieves the epoch for the event data most recently retrieved. Added in NDB 7.4.3.
`getEventType()`	Gets the event type. Deprecated in NDB 7.4.3.
`getEventType2()`	Gets the event type. Added in NDB 7.4.3.
`getGCI()`	Retrieves the GCI of the most recently retrieved event. Deprecated in NDB 7.4.3.
`getLatestGCI()`	Retrieves the most recent GCI (whether or not the corresponding event has been retrieved). Deprecated in NDB 7.4.3.
`getNdbError()`	Gets the most recent error
`getPreBlobHandle()`	Gets a handle for reading the previous blob attribute
`getPreValue()`	Retrieves an attribute's previous value
`getState()`	Gets the current state of the event operation
`getValue()`	Retrieves an attribute value
`hasError()`	Whether an error has occurred as part of this operation. Deprecated in NDB 7.4.3.
`isConsistent()`	Detects event loss caused by node failure. Deprecated in NDB 7.4.3.
`isEmptyEpoch()`	Detects an empty epoch. Added in NDB 7.4.3.

Name	Description
`isErrorEpoch()`	Detects an error epoch, and retrieves the error if there is one. Added in NDB 7.4.3.
`isOverrun()`	Whether event loss has taken place due to a buffer overrun. Deprecated in NDB 7.4.3.
`mergeEvents()`	Makes it possible for events to be merged
`tableFragmentationChanged()`	Checks to see whether the fragmentation for a table has changed
`tableFrmChanged()`	Checks to see whether a table `.FRM` file has changed
`tableNameChanged()`	Checks to see whether the name of a table has changed
`tableRangeListChanged()`	Checks to see whether a table range partition list name has changed

Types. `NdbEventOperation` defines one enumerated type, the `State` type.

2.3.21.1 NdbEventOperation::clearError()

Description. Clears the error most recently associated with this event operation.

This method is deprecated in NDB 7.4.3, and is subject to removal in a future release.

Signature.

```
void clearError
    (
      void
    )
```

Parameters. *None*.

Return value. *None*.

2.3.21.2 NdbEventOperation::execute()

Description. Activates the `NdbEventOperation`, so that it can begin receiving events. Changed attribute values may be retrieved after `Ndb::nextEvent()` has returned a value other than `NULL`.

One of `getValue()`, `getPreValue()`, `getBlobValue()`, or `getPreBlobValue()` must be called before invoking `execute()`.

Important

Before attempting to use this method, you should have read the explanations provided in Section 2.3.16.25, “Ndb::nextEvent()”, and Section 2.3.21.13, “NdbEventOperation::getValue()”. Also see Section 2.3.21, “The NdbEventOperation Class”.

Signature.

```
int execute
    (
      void
    )
```

Parameters. *None*.

Return value. This method returns `0` on success and `-1` on failure.

2.3.21.3 NdbEventOperation::getBlobHandle()

Description. This method is used in place of `getValue()` for blob attributes. The blob handle (`NdbBlob`) returned by this method supports read operations only.

> **Note**
>
> To obtain the previous value for a blob attribute, use `getPreBlobHandle()`.

Signature.

```
NdbBlob* getBlobHandle
    (
      const char* name
    )
```

Parameters. The *`name`* of the blob attribute.

Return value. A pointer to an `NdbBlob` object.

2.3.21.4 NdbEventOperation::getEpoch()

Description. Gets the epoch for the latest event data retrieved.

Added in NDB 7.4.3, this method supersedes `getGCI()`, which is now deprecated and subject to removal in a future NDB Cluster release.

Signature.

```
Uint64 getEpoch
  (
    void
  ) const
```

Parameters. *None*.

Return value. An epoch number (an integer).

2.3.21.5 NdbEventOperation::getEventType()

Description. This method is used to obtain the event's type (`TableEvent`).

This method is deprecated in NDB 7.4.3, and is subject to removal in a future release. In NDB 7.4.3 and later, you should use `getEventType2()` instead.

Signature.

```
NdbDictionary::Event::TableEvent getEventType
    (
      void
    ) const
```

Parameters. *None*.

Return value. A `TableEvent` value.

2.3.21.6 NdbEventOperation::getEventType2()

Description. This method is used to obtain the event's type (`TableEvent`).

Added in NDB 7.4.3, this method supersedes `getEventType()`, which is now deprecated and subject to removal in a future NDB Cluster release.

Signature.

```
NdbDictionary::Event::TableEvent getEventType2
    (
      void
    ) const
```

Parameters. *None*.

Return value. A `TableEvent` value.

2.3.21.7 NdbEventOperation::getGCI()

Description. This method retrieves the GCI for the most recently retrieved event.

This method is deprecated in NDB 7.4.3, and is subject to removal in a future release. In NDB 7.4.3 and later, you should use `getEpoch()` instead.

Signature.

```
Uint64 getGCI
    (
      void
    ) const
```

Parameters. *None*.

Return value. The global checkpoint index of the most recently retrieved event (an integer).

2.3.21.8 NdbEventOperation::getLatestGCI()

Description. This method retrieves the most recent GCI.

This method returns the latest epoch number.

This method is deprecated in NDB 7.4.3, and is subject to removal in a future release. In NDB 7.4.3 and later, you should use `Ndb::getHighestQueuedEpoch()` instead.

Note

The GCI obtained using this method is not necessarily associated with an event.

Signature.

```
Uint64 getLatestGCI
    (
      void
    ) const
```

Parameters. *None*.

Return value. The index of the latest global checkpoint, an integer.

2.3.21.9 NdbEventOperation::getNdbError()

Description. This method retrieves the most recent error.

Signature.

```
const struct NdbError& getNdbError
    (
      void
```

```
    ) const
```

Parameters. *None*.

Return value. A reference to an `NdbError` structure.

2.3.21.10 NdbEventOperation::getPreBlobHandle()

Description. This function is the same as `getBlobHandle()`, except that it is used to access the previous value of the blob attribute. See Section 2.3.21.3, "NdbEventOperation::getBlobHandle()".

Signature.

```
NdbBlob* getPreBlobHandle
  (
    const char* name
  )
```

Parameters. The *`name`* of the blob attribute.

Return value. A pointer to an `NdbBlob`.

2.3.21.11 NdbEventOperation::getPreValue()

Description. This method performs identically to getValue(), except that it is used to define a retrieval operation of an attribute's previous value rather than the current value. See Section 2.3.21.13, "NdbEventOperation::getValue()", for details.

Signature.

```
NdbRecAttr* getPreValue
    (
      const char* name,
      char*       value = 0
    )
```

Parameters. This method takes the two parameters listed here:

- The *`name`* of the attribute (as a constant character pointer).
- A pointer to a *`value`*, such that:
  - If the attribute value is not `NULL`, then the attribute value is returned in this parameter.
  - If the attribute value is `NULL`, then the attribute value is stored only in the `NdbRecAttr` object returned by this method.

  See *`value`* Buffer Memory Allocation, for more information regarding this parameter.

Return value. An `NdbRecAttr` object to hold the value of the attribute, or a `NULL` pointer indicating that an error has occurred.

2.3.21.12 NdbEventOperation::getState()

Description. This method gets the event operation's current state.

Signature.

```
State getState
    (
      void
    )
```

Parameters. *None*.

Return value. A `State` value. See Section 2.3.21.20, “NdbEventOperation::State”.

2.3.21.13 NdbEventOperation::getValue()

Description. This method defines the retrieval of an attribute value. The NDB API allocates memory for the `NdbRecAttr` object that is to hold the returned attribute value.

> **Important**
>
> This method does *not* fetch the attribute value from the database, and the `NdbRecAttr` object returned by this method is not readable or printable before calling the `execute()` method and `Ndb::nextEvent()` has returned a non-`NULL` value.
>
> If a specific attribute has not changed, the corresponding `NdbRecAttr` will be in the state `UNDEFINED`. This can be checked by using `NdbRecAttr::isNULL()` which in such cases returns `-1`.

***`value`* Buffer Memory Allocation.** It is the application's responsibility to allocate sufficient memory for the *`value`* buffer (if not `NULL`), and this buffer must be aligned appropriately. The buffer is used directly (thus avoiding a copy penalty) only if it is aligned on a 4-byte boundary and the attribute size in bytes (calculated as `NdbRecAttr::get_size_in_bytes()`) is a multiple of 4.

> **Note**
>
> `getValue()` retrieves the current value. Use `getPreValue()` for retrieving the previous value.

Signature.

```
NdbRecAttr* getValue
    (
      const char* name,
      char*       value = 0
    )
```

Parameters. This method takes the two parameters listed here:

- The *`name`* of the attribute (as a constant character pointer).
- A pointer to a *`value`*, such that:
  - If the attribute value is not `NULL`, then the attribute value is returned in this parameter.
  - If the attribute value is `NULL`, then the attribute value is stored only in the `NdbRecAttr` object returned by this method.

  See *`value`* Buffer Memory Allocation, for more information regarding this parameter.

Return value. An `NdbRecAttr` object to hold the value of the attribute, or a `NULL` pointer indicating that an error has occurred.

2.3.21.14 NdbEventOperation::hasError()

Description. This method is used to determine whether there is an error associated with this event operation.

This method is deprecated in NDB 7.4.3, and is subject to removal in a future release. In NDB 7.4.3 and later, you should instead use `getEventType2()` to determine the event type. See Section 2.3.6.23, “Event::TableEvent”.

Signature.

```
int hasError
    (
      void
    ) const
```

Parameters. *None*.

Return value. If event loss has taken place, then this method returns 0; otherwise, it returns 1.

2.3.21.15 NdbEventOperation::isConsistent()

Description. This method is used to determine whether event loss has taken place following the failure of a node.

This method is deprecated in NDB 7.4.3, and is subject to removal in a future release. In NDB 7.4.3 and later, you should instead use `getEventType2()` to determine whether the event is of type `TE_INCONSISTENT`. See Section 2.3.6.23, “Event::TableEvent”.

Signature.

```
bool isConsistent
    (
      void
    ) const
```

Parameters. *None*.

Return value. If event loss has taken place, then this method returns `false`; otherwise, it returns `true`.

2.3.21.16 NdbEventOperation::isEmptyEpoch()

Description. This method is used to determine whether consumed event data marks an empty epoch.

This method was added in NDB 7.4.3.

Signature.

```
bool isEmptyEpoch
    (
      void
    )
```

Parameters. *None*.

Return value. If this epoch is empty, the method returns `true`; otherwise, it returns `false`.

2.3.21.17 NdbEventOperation::isErrorEpoch()

Description. This method is used to determine whether consumed event data marks an empty epoch.

This method was added in NDB 7.4.3.

Signature.

```
bool isErrorEpoch
  (
    NdbDictionary::Event::TableEvent* error_type = 0
```

```
  )
```

Parameters. If this is an error epoch, *`error_type`* contains the `TableEvent` value corresponding to the error.

Return value. If this epoch is in error, the method returns `true`; otherwise, it returns `false`.

2.3.21.18 NdbEventOperation::isOverrun()

Description. This method is used to determine whether event loss has taken place due to a buffer overrun.

Signature.

```
bool isOverrun
    (
      void
    ) const
```

Parameters. *None*.

Return value. If the event buffer has been overrun, then this method returns `true`, otherwise, it returns `false`.

2.3.21.19 NdbEventOperation::mergeEvents()

Description. This method is used to set the merge events flag. For information about event merging, see Section 2.3.6.18, "Event::mergeEvents()".

> **Note**
>
> The merge events flag is `false` by default.

Signature.

```
void mergeEvents
    (
      bool flag
    )
```

Parameters. A Boolean *`flag`*.

Return value. *None*.

2.3.21.20 NdbEventOperation::State

Description. This type describes the event operation's state.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.39 NdbEventOperation data type values and descriptions

Name	Description
`EO_CREATED`	The event operation has been created, but `execute()` has not yet been called.
`EO_EXECUTING`	The `execute()` method has been invoked for this event operation.
`EO_DROPPED`	The event operation is waiting to be deleted, and is no longer usable.

Name	Description
EO_ERROR	An error has occurred, and the event operation is unusable.

A State value is returned by the getState() method.

2.3.21.21 NdbEventOperation::tableFragmentationChanged()

Description. This method is used to test whether a table's fragmentation has changed in connection with a TE_ALTER event. (See Section 2.3.6.23, "Event::TableEvent".)

Signature.

```
bool tableFragmentationChanged
    (
      void
    ) const
```

Parameters. *None*.

Return value. Returns true if the table's fragmentation has changed; otherwise, the method returns false.

2.3.21.22 NdbEventOperation::tableFrmChanged()

Description. Use this method to determine whether a table .FRM file has changed in connection with a TE_ALTER event. (See Section 2.3.6.23, "Event::TableEvent".)

Signature.

```
bool tableFrmChanged
    (
      void
    ) const
```

Parameters. *None*.

Return value. Returns true if the table .FRM file has changed; otherwise, the method returns false.

2.3.21.23 NdbEventOperation::tableNameChanged()

Description. This method tests whether a table name has changed as the result of a TE_ALTER table event. (See Section 2.3.6.23, "Event::TableEvent".)

Signature.

```
bool tableNameChanged
    (
      void
    ) const
```

Parameters. *None*.

Return value. Returns true if the name of the table has changed; otherwise, the method returns false.

2.3.21.24 NdbEventOperation::tableRangeListChanged()

Description. Use this method to check whether a table range partition list name has changed in connection with a TE_ALTER event.

Signature.

```
bool tableRangeListChanged
    (
      void
    ) const
```

Parameters. *None*.

Return value. This method returns `true` if range or list partition name has changed; otherwise it returns `false`.

2.3.22 The NdbIndexOperation Class

This section describes the `NdbIndexOperation` class and its public methods.

Parent class. `NdbOperation`

Child classes. *None*

Description. `NdbIndexOperation` represents an index operation for use in transactions. This class inherits from `NdbOperation`.

`NdbIndexOperation` can be used only with unique hash indexes; to work with ordered indexes, use `NdbIndexScanOperation`.

Important

This class has no public constructor. To create an instance of `NdbIndexOperation`, it is necessary to use the `NdbTransaction::getNdbIndexOperation()` method.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.40 NdbIndexOperation class methods and descriptions

Name	Description
`deleteTuple()`	Removes a tuple from a table
`getIndex()`	Gets the index used by the operation
`readTuple()`	Reads a tuple from a table
`updateTuple()`	Updates an existing tuple in a table

Note

Index operations are not permitted to insert tuples.

Types. The `NdbIndexOperation` class defines no public types of its own.

For more information about the use of `NdbIndexOperation`, see Single-row operations.

2.3.22.1 NdbIndexOperation::deleteTuple()

Description. This method defines the `NdbIndexOperation` as a `DELETE` operation. When the `NdbTransaction::execute()` method is invoked, the operation deletes a tuple from the table.

Signature.

```
int deleteTuple
    (
```

```
      void
    )
```

Parameters. *None*.

Return value. `0` on success, `-1` on failure.

2.3.22.2 NdbIndexOperation::getIndex()

Description. Gets the index, given an index operation.

Signature.

```
const NdbDictionary::Index* getIndex
    (
      void
    ) const
```

Parameters. *None*.

Return value. A pointer to an `Index` object.

2.3.22.3 NdbIndexOperation::readTuple()

Description. This method defines the `NdbIndexOperation` as a `READ` operation. When the `NdbTransaction::execute()` method is invoked, the operation reads a tuple.

Signature.

```
int readTuple
    (
      LockMode mode
    )
```

Parameters. *`mode`* specifies the locking mode used by the read operation. See Section 2.3.25.15, “NdbOperation::LockMode”, for possible values.

Return value. `0` on success, `-1` on failure.

2.3.22.4 NdbIndexOperation::updateTuple()

Description. This method defines the `NdbIndexOperation` as an `UPDATE` operation. When the `NdbTransaction::execute()` method is invoked, the operation updates a tuple found in the table.

Signature.

```
int updateTuple
    (
      void
    )
```

Parameters. *None*.

Return value. `0` on success, `-1` on failure.

2.3.23 The NdbIndexScanOperation Class

This section discusses the `NdbIndexScanOperation` class and its public members.

Parent class. `NdbScanOperation`

Child classes. *None*

Description. The `NdbIndexScanOperation` class represents a scan operation using an ordered index. This class inherits from `NdbScanOperation` and `NdbOperation`.

> **Note**
>
> `NdbIndexScanOperation` is for use with ordered indexes only; to work with unique hash indexes, use `NdbIndexOperation`.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.41 NdbIndexScanOperation class methods and descriptions

Name	Description
`end_of_bound()`	Marks the end of a bound
`get_range_no()`	Gets the range number for the current row
`getDescending()`	Checks whether the current scan is sorted
`getSorted()`	Checks whether the current scan is sorted
`readTuples()`	Reads tuples using an ordered index
`reset_bounds()`	Resets bounds, puts the operation in the send queue
`setBound()`	Defines a bound on the index key for a range scan

Types. The `NdbIndexScanOperation` class defines one public type `BoundType`.

This class also defines an `IndexBound` struct, for use with operations employing `NdbRecord`.

For more information about the use of `NdbIndexScanOperation`, see Scan Operations, and Using Scans to Update or Delete Rows

2.3.23.1 NdbIndexScanOperation::BoundType

Description. This type is used to describe an ordered key bound.

> **Tip**
>
> The numeric values are fixed in the API and can be used explicitly; in other words, it is “safe” to calculate the values and use them.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.42 NdbIndexScanOperation::BoundType values, numeric equivalents, and descriptions

Value	Numeric Value	Description
`BoundLE`	`0`	Lower bound
`BoundLT`	`1`	Strict lower bound
`BoundGE`	`2`	Upper bound
`BoundGT`	`3`	Strict upper bound
`BoundEQ`	`4`	Equality

2.3.23.2 NdbIndexScanOperation::end_of_bound()

Description. This method is used to mark the end of a bound; it is used when batching index reads (that is, when employing multiple ranges).

Signature.

```
int end_of_bound
    (
      Uint32 range_no
    )
```

Parameters. The number of the range on which the bound occurs.

Return value. `0` indicates success; `-1` indicates failure.

2.3.23.3 NdbIndexScanOperation::getDescending()

Description. This method is used to check whether the scan is descending.

Signature.

```
bool getDescending
    (
      void
    ) const
```

Parameters. *None*.

Return value. This method returns `true` if the scan is sorted in descending order; otherwise, it returns `false`.

2.3.23.4 NdbIndexScanOperation::get_range_no()

Description. This method returns the range number for the current row.

Signature.

```
int get_range_no
    (
      void
    )
```

Parameters. *None*.

Return value. The range number (an integer).

2.3.23.5 NdbIndexScanOperation::getSorted()

Description. This method is used to check whether the scan is sorted.

Signature.

```
bool getSorted
    (
      void
    ) const
```

Parameters. *None*.

Return value. `true` if the scan is sorted, otherwise `false`.

2.3.23.6 NdbIndexScanOperation::readTuples()

Description. This method is used to read tuples, using an ordered index.

Signature.

```
virtual int readTuples
    (
      LockMode mode = LM_Read,
      Uint32   flags = 0,
      Uint32   parallel = 0,
      Uint32   batch = 0

    )
```

Parameters. The `readTuples()` method takes the three parameters listed here:

- The lock *`mode`* used for the scan. This is a `LockMode` value; see Section 2.3.25.15, “NdbOperation::LockMode” for more information, including permitted values.
- One or more scan flags; multiple *`flags`* are `OR`'ed together as they are when used with `NdbScanOperation::readTuples()`. See Section 2.3.29.9, “NdbScanOperation::ScanFlag” for possible values.
- The number of fragments to scan in *`parallel`*; use `0` to specify the maximum automatically.
- The *`batch`* parameter specifies how many records will be returned to the client from the server by the next `NdbScanOperation::nextResult(true)` method call. Use `0` to specify the maximum automatically.

> **Note**
>
> This parameter was ignored prior to MySQL 5.1.12, and the maximum was used.(Bug #20252)

Return value. An integer: `0` indicates success; `-1` indicates failure.

2.3.23.7 NdbIndexScanOperation::reset_bounds()

Description. Resets the bounds, and puts the operation into the list that will be sent on the next `NdbTransaction::execute()` call.

Signature.

```
int reset_bounds
    (
      bool forceSend = false
    )
```

Parameters. Set *`forceSend`* to `true` in order to force the operation to be sent immediately.

Return value. Returns `0` on success, `-1` on failure.

2.3.23.8 NdbIndexScanOperation::setBound()

Description. This method defines a bound on an index key used in a range scan, and sets bounds for index scans defined using `NdbRecord`.

"Old" API usage (prior to introduction of NdbRecord). Each index key can have a lower bound, upper bound, or both. Setting the key equal to a value defines both upper and lower bounds. Bounds can be defined in any order. Conflicting definitions gives rise to an error.

Bounds must be set on initial sequences of index keys, and all but possibly the last bound must be nonstrict. This means, for example, that “a >= 2 AND b > 3” is permissible, but “a > 2 AND b >= 3” is not.

The scan may currently return tuples for which the bounds are not satisfied. For example, a `<= 2 && b <= 3` not only scans the index up to `(a=2, b=3)`, but also returns any `(a=1, b=4)` as well.

When setting bounds based on equality, it is better to use `BoundEQ` instead of the equivalent pair `BoundLE` and `BoundGE`. This is especially true when the table partition key is a prefix of the index key.

`NULL` is considered less than any non-`NULL` value and equal to another `NULL` value. To perform comparisons with `NULL`, use `setBound()` with a null pointer (`0`).

An index also stores all-`NULL` keys as well, and performing an index scan with an empty bound set returns all tuples from the table.

Signature ("Old" API). Using the "old" API, this method could be called in either of two ways. Both of these use the bound type and value; the first also uses the name of the bound, as shown here:

```
int setBound
    (
      const char* name,
      int         type,
      const void* value
    )
```

The second way to invoke this method under the "old" API uses the bound's ID rather than the name, as shown here:

```
int setBound
    (
      Uint32      id,
      int         type,
      const void* value
    )
```

Parameters ("Old" API). This method takes 3 parameters:

- Either the *`name`* or the *`id`* of the attribute on which the bound is to be set.
- The bound `type`—see Section 2.3.23.1, "NdbIndexScanOperation::BoundType".
- A pointer to the bound *`value`* (use `0` for `NULL`).

As used with NdbRecord. This method is called to add a range to an index scan operation which has been defined with a call to `NdbTransaction::scanIndex()`. To add more than one range, the index scan operation must have been defined with the `SF_MultiRange` flag set. (See Section 2.3.29.9, "NdbScanOperation::ScanFlag".)

Note

Where multiple numbered ranges are defined with multiple calls to `setBound()`, and the scan is ordered, the range number for each range must be larger than the range number for the previously defined range.

Signature.

```
int setBound
    (
      const NdbRecord* keyRecord,
      const IndexBound& bound
    )
```

Parameters. As used with `NdbRecord`, this method takes 2 parameters, listed here:

- *`keyRecord`*: This is an `NdbRecord` structure corresponding to the key on which the index is defined.
- The *`bound`* to add (see Section 2.3.12, "The IndexBound Structure").

An additional version of this method can be used when the application knows that rows in-range will be found only within a particular partition. This is the same as that shown previously, except for the addition of a `PartitionSpec`. Doing so limits the scan to a single partition, improving system efficiency.

Signature (when specifying a partition).

```
int setBound
    (
      const NdbRecord* keyRecord,
      const IndexBound& bound,
      const Ndb::PartitionSpec* partInfo,
      Uint32 sizeOfPartInfo = 0
    )
```

Parameters (when specifying a partition). This method can also be invoked with the following four parameters:

- *`keyRecord`*: This is an `NdbRecord` structure corresponding to the key on which the index is defined.
- The *`bound`* to be added to the scan (see Section 2.3.12, “The IndexBound Structure”).
- *`partInfo`*: This is a pointer to a `PartitionSpec`, which provides extra information making it possible to scan a reduced set of partitions.
- *`sizeOfPartInfo`*: The length of the partition specification.

Note

`keyRecord` and *`bound`* are defined and used in the same way as with the 2-parameter version of this method.

Return value. Returns `0` on success, `-1` on failure.

2.3.24 The NdbInterpretedCode Class

This section discusses the `NdbInterpretedCode` class, which can be used to prepare and execute an NDB API interpreted program.

Parent class. *None*.

Child classes. *None*.

Description. `NdbInterpretedCode` represents an interpreted program for use in operations created using `NdbRecord`, or with scans created using the old API. The `NdbScanFilter` class can also be used to generate an NDB interpreted program using this class.

Important

This interface is still under development, and so is subject to change without notice. The `NdbScanFilter` API is a more stable API for defining scanning and filtering programs.

Using NdbInterpretedCode. To create an `NdbInterpretedCode` object, invoke the constructor, optionally supplying a table for the program to operate on, and a buffer for program storage and finalization. If no table is supplied, then only instructions which do not access table attributes can be used. Beginning with NDB 8.0.18, an instance of `Ndbrecord` can be used for this purpose, in place of the `Table`.

Note

Each NDB API operation applies to one table, and so does any `NdbInterpretedCode` program attached to that operation.

If no buffer is supplied, then an internal buffer is dynamically allocated and extended as necessary. Once the `NdbInterpretedCode` object is created, you can add instructions and labels to it by calling the appropriate methods as described later in this section. When the program has completed, finalize it by calling the `finalise()` method, which resolves any remaining internal branches and calls to label and subroutine offsets.

Note

A single finalized `NdbInterpretedCode` program can be used by more than one operation. It need not be re-prepared for successive operations.

To use the program with `NdbRecord` operations and scans, pass it at operation definition time using the `OperationOptions` or `ScanOptions` parameter. When the program is no longer required, the `NdbInterpretedCode` object can be deleted, along with any user-supplied buffer.

Error checking. For reasons of efficiency, methods of this class provide minimal error checking.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.43 NdbInterpretedCode class methods and descriptions

Name	Description
`NdbInterpretedCode()`	Class constructor
`add_reg()`	Add two register values and store the result in a third register
`add_val()`	Add a value to a table column value
`branch_col_and_mask_eq_mask()`	Jump if a column value `AND`ed with a bitmask is equal to the bitmask
`branch_col_and_mask_eq_zero()`	Jump if a column value `AND`ed with a bitmask is equal to `0`
`branch_col_and_mask_ne_mask()`	Jump if a column value `AND`ed with a bitmask is not equal to the bitmask
`branch_col_and_mask_ne_zero()`	Jump if a column value `AND`ed with a bitmask is not equal to `0`
`branch_col_eq()`	Jump if a column value is equal to another
`branch_col_eq_null()`	Jump if a column value is `NULL`
`branch_col_ge()`	Jump if a column value is greater than or equal to another
`branch_col_gt()`	Jump if a column value is greater than another
`branch_col_le()`	Jump if a column value is less than or equal to another
`branch_col_like()`	Jump if a column value matches a pattern
`branch_col_lt()`	Jump if a column value is less than another
`branch_col_ne()`	Jump if a column value is not equal to another
`branch_col_ne_null()`	Jump if a column value is not `NULL`
`branch_col_notlike()`	Jump if a column value does not match a pattern
`branch_eq()`	Jump if one register value is equal to another
`branch_eq_null()`	Jump if a register value is `NULL`
`branch_ge()`	Jump if one register value is greater than or equal to another
`branch_gt()`	Jump if one register value is greater than another
`branch_label()`	Unconditional jump to a label
`branch_le()`	Jump if one register value is less than or equal to another
`branch_lt()`	Jump if one register value is less than another

Name	Description
`branch_ne()`	Jump if one register value is not equal to another
`branch_ne_null()`	Jump if a register value is not `NULL`
`call_sub()`	Call a subroutine
`copy()`	Make a deep copy of an `NdbInterpretedCode` object
`def_label()`	Create a label for use within the interpreted program
`def_sub()`	Define a subroutine
`finalise()`	Completes interpreted program and prepares it for use
`getNdbError()`	Gets the most recent error associated with this `NdbInterpretedCode` object
`getTable()`	Gets the table on which the program is defined
`getWordsUsed()`	Gets the number of words used in the buffer
`interpret_exit_last_row()`	Return a row as part of the result, and do not check any more rows in this fragment
`interpret_exit_nok()`	Do not return a row as part of the result
`interpret_exit_ok()`	Return a row as part of the result
`load_const_null()`	Load a `NULL` value into a register
`load_const_u16()`	Load a 16-bit numeric value into a register
`load_const_u32()`	Load a 32-bit numeric value into a register
`load_const_u64()`	Load a 64-bit numeric value into a register
`read_attr()`	Read a table column value into a register
`ret_sub()`	Return from a subroutine
`sub_reg()`	Subtract two register values and store the result in a third register
`sub_val()`	Subtract a value from a table column value
`write_attr()`	Write a register value into a table column

See also Section 2.3.24.1, “Using NdbInterpretedCode”.

Types. This class defines no public types.

2.3.24.1 Using NdbInterpretedCode

The next few sections provide information about performing different types of operations with `NdbInterpretedCode` methods, including resource usage.

NdbInterpretedCode Methods for Loading Values into Registers

The methods described in this section are used to load constant values into `NdbInterpretedCode` program registers. The space required by each of these methods is shown in the following table:

Table 2.44 NdbInterpretedCode methods used to load constant values into NdbInterpretedCode program registers, with required buffer and request message space.

Method	Buffer (words)	Request message (words)
`load_const_null()`	1	1
`load_const_u16()`	1	1
`load_const_u32()`	2	2

Method	Buffer (words)	Request message (words)
`load_const_u64()`	3	3

NdbInterpretedCode Methods for Copying Values Between Registers and Table Columns

`NdbInterpretedCode` provides two methods for copying values between a column in the current table row and a program register. The `read_attr()` method is used to copy a table column value into a program register; `write_attr()` is used to copy a value from a program register into a table column. Both of these methods require that the table being operated on was specified when creating the `NdbInterpretedCode` object for which they are called.

The space required by each of these methods is shown in the following table:

Table 2.45 NdbInterpretedCode methods used to copy values between registers and table columns, with required buffer and request message space.

Method	Buffer (words)	Request message (words)
`read_attr()`	1	1
`write_attr()`	1	1

For more information, see Section 2.3.24.43, "NdbInterpretedCode::read_attr()", and Section 2.3.24.47, "NdbInterpretedCode::write_attr()".

NdbInterpretedCode Register Arithmetic Methods

`NdbInterpretedCode` provides two methods for performing arithmetic operations on registers. Using `add_reg()`, you can load the sum of two registers into another register; `sub_reg()` lets you load the difference of two registers into another register.

The space required by each of these methods is shown in the following table:

Table 2.46 NdbInterpretedCode methods used to perform arithmetic operations on registers, with required buffer and request message space.

Method	Buffer (words)	Request message (words)
`add_reg()`	1	1
`sub_reg()`	1	1

For mroe information, see Section 2.3.24.3, "NdbInterpretedCode::add_reg()", and Section 2.3.24.45, "NdbInterpretedCode::sub_reg()".

NdbInterpretedCode: Labels and Branching

The `NdbInterpretedCode` class lets you define labels within interpreted programs and provides a number of methods for performing jumps to these labels based on any of the following types of conditions:

- Comparison between two register values
- Comparison between a column value and a given constant
- Whether or not a column value matches a given pattern

To define a label, use the `def_label()` method.

To perform an unconditional jump to a label, use the `branch_label()` method.

To perform a jump to a given label based on a comparison of register values, use one of the `branch_*()` methods (`branch_ge()`, `branch_gt()`, `branch_le()`, `branch_lt()`, `branch_eq()`, `branch_ne()`, `branch_ne_null()`, or `branch_eq_null()`). See Register-Based NdbInterpretedCode Branch Operations.

To perform a jump to a given label based on a comparison of table column values, use one of the `branch_col_*()` methods (`branch_col_ge()`, `branch_col_gt()`, `branch_col_le()`, `branch_col_lt()`, `branch_col_eq()`, `branch_col_ne()`, `branch_col_ne_null()`, or `branch_col_eq_null()`). See Column-Based NdbInterpretedCode Branch Operations.

To perform a jump based on pattern-matching of a table column value, use one of the methods `branch_col_like()` or `branch_col_notlike()`. See Pattern-Based NdbInterpretedCode Branch Operations.

Register-Based NdbInterpretedCode Branch Operations

Most of these are used to branch based on the results of register-to-register comparisons. There are also two methods used to compare a register value with `NULL`. All of these methods require as a parameter a label defined using the `def_label()` method.

These methods can be thought of as performing the following logic:

```
if(register_value1 condition register_value2)
  goto Label
```

The space required by each of these methods is shown in the following table:

Table 2.47 Register-based NdbInterpretedCode branch methods, with required buffer and request message space.

Method	Buffer (words)	Request message (words)
`branch_ge()`	1	1
`branch_gt()`	1	1
`branch_le()`	1	1
`branch_lt()`	1	1
`branch_eq()`	1	1
`branch_ne()`	1	1
`branch_ne_null()`	1	1
`branch_eq_null()`	1	1

Column-Based NdbInterpretedCode Branch Operations

The methods described in this section are used to perform branching based on a comparison between a table column value and a given constant value. Each of these methods expects the attribute ID of the column whose value is to be tested rather than a reference to a `Column` object.

These methods, with the exception of `branch_col_eq_null()` and `branch_col_ne_null()`, can be thought of as performing the following logic:

```
if(constant_value condition column_value)
  goto Label
```

In each case (once again excepting `branch_col_eq_null()` and `branch_col_ne_null()`), the arbitrary constant is the first parameter passed to the method.

The space requirements for each of these methods is shown in the following table, where *L* represents the length of the constant value:

Table 2.48 Column-based NdbInterpretedCode branch methods, with required buffer and request message space.

Method	Buffer (words)	Request message (words)
`branch_col_eq_null()`	2	2
`branch_col_ne_null()`	2	2
`branch_col_eq()`	2	2 + `CEIL(L / 8)`
`branch_col_ne()`	2	2 + `CEIL(L / 8)`
`branch_col_lt()`	2	2 + `CEIL(L / 8)`
`branch_col_le()`	2	2 + `CEIL(L / 8)`
`branch_col_gt()`	2	2 + `CEIL(L / 8)`
`branch_col_ge()`	2	2 + `CEIL(L / 8)`

Note

The expression `CEIL(L / 8)` is the number of whole 8-byte words required to hold the constant value to be compared.

Pattern-Based NdbInterpretedCode Branch Operations

The `NdbInterpretedCode` class provides two methods which can be used to branch based on a comparison between a column containing character data (that is, a `CHAR`, `VARCHAR`, `BINARY`, or `VARBINARY` column) and a regular expression pattern.

The pattern syntax supported by the regular expression is the same as that supported by the MySQL Server's `LIKE` and `NOT LIKE` operators, including the `_` and `%` metacharacters. For more information about these, see String Comparison Functions and Operators.

Note

This is the same regular expression pattern syntax that is supported by `NdbScanFilter`; see Section 2.3.28.3, “NdbScanFilter::cmp()”, for more information.

The table being operated upon must be supplied when the `NdbInterpretedCode` object is instantiated. The regular expression pattern should be in plain `CHAR` format, even if the column is actually a `VARCHAR` (in other words, there should be no leading length bytes).

These functions behave as shown here:

```
if (column_value [NOT] LIKE pattern)
  goto Label;
```

The space requirements for these methods are shown in the following table, where *L* represents the length of the constant value:

Table 2.49 Pattern-based NdbInterpretedCode branch methods, with required buffer and request message space.

Method	Buffer (words)	Request message (words)
`branch_col_like()`	2	2 + `CEIL(L / 8)`

Method	Buffer (words)	Request message (words)
`branch_col_notlike()`	2	2 + `CEIL(L / 8)`

Note

The expression `CEIL(L / 8)` is the number of whole 8-byte words required to hold the constant value to be compared.

NdbInterpretedCode Bitwise Comparison Operations

These instructions are used to branch based on the result of a logical `AND` comparison between a `BIT` column value and a bitmask pattern.

Use of these methods requires that the table being operated upon was supplied when the `NdbInterpretedCode` object was constructed. The mask value should be the same size as the bit column being compared. `BIT` values are passed into and out of the NDB API as 32-bit words with bits set in order from the least significant bit to the most significant bit. The endianness of the platform on which the instructions are executed controls which byte contains the least significant bits. On x86, this is the first byte (byte 0); on SPARC and PPC, it is the last byte.

The buffer length and the request length for each of the methods listed here each requires an amount of space equal to 2 words plus the column width rounded (up) to the nearest whole word:

- `branch_col_and_mask_eq_mask()`
- `branch_col_and_mask_ne_mask()`
- `branch_col_and_mask_eq_zero()`
- `branch_col_and_mask_ne_zero()`

NdbInterpretedCode Result Handling Methods

The methods described in this section are used to tell the interpreter that processing of the current row is complete, and—in the case of scans—whether or not to include this row in the results of the scan.

The space requirements for these methods are shown in the following table, where *`L`* represents the length of the constant value:

Table 2.50 NdbInterpretedCode result handling methods, with required buffer and request message space.

Method	Buffer (words)	Request message (words)
`interpret_exit_ok()`	1	1
`interpret_exit_nok()`	1	1
`interpret_exit_last_row()`	1	1

NdbInterpretedCode Convenience Methods

The methods described in this section can be used to insert multiple instructions (using specific registers) into an interpreted program.

Important

In addition to updating the table column, these methods use interpreter registers 6 and 7, replacing any existing contents of register 6 with the original column value and any existing contents of register 7 with the modified column value. The table itself must be previously defined when instantiating the `NdbInterpretedCode` object for which the method is invoked.

The space requirements for these methods are shown in the following table, where *`L`* represents the length of the constant value:

Table 2.51 NdbInterpretedCode convenience methods, with required buffer and request message space.

Method	Buffer (words)	Request message (words)
`add_val()`	4	1; if the supplied value >= 2^{16}: 2; if >= 2^{32}: 3
`sub_val()`	4	1; if the supplied value >= 2^{16}: 2; if >= 2^{32}: 3

Using Subroutines with NdbInterpretedCode

`NdbInterpretedCode` supports subroutines which can be invoked from within interpreted programs, with each subroutine being identified by a unique number. Subroutines can be defined only following all main program instructions.

Important

Numbers used to identify subroutines must be contiguous; however, they do not have to be in any particular order.

- The beginning of a subroutine is indicated by invoking the `def_sub()` method;
- `ret_sub()` terminates the subroutine; all instructions following the call to `def_sub()` belong to the subroutine until it is terminated using this method.
- A subroutine is called using the `call_sub()` method.

Once the subroutine has completed, the program resumes execution with the instruction immediately following the one which invoked the subroutine. Subroutines can also be invoked from other subroutines; currently, the maximum subroutine stack depth is 32.

NdbInterpretedCode Utility Methods

Some additional utility methods supplied by `NdbInterpretedCode` are listed here:

- `copy()`: Copies an existing interpreted program by performing a deep copy on the associated `NdbInterpretedCode` object.
- `finalise()`: Prepares an interpreted program by resolving all branching instructions and subroutine calls.
- `getTable()`: Get a reference to the table for which the `NdbInterpretedCode` object was defined.
- `getNdbError()`: Get the most recent error associated with this `NdbInterpretedCode` object.
- `getWordsUsed()`: Obtain the number of words used from the buffer.

2.3.24.2 NdbInterpretedCode Constructor

Description. This is the `NdbInterpretedCode` class constuctor.

Signature.

```
NdbInterpretedCode
    (
      const NdbDictionary::Table* table = 0,
      Uint32* buffer = 0,
      Uint32 buffer_word_size = 0
    )
```

Alternative constructor (NDB 8.0.18 and later).

```
NdbInterpretedCode
    (
      const NdbRecord&,
      Uint32* buffer = 0,
      Uint32 buffer_word_size = 0);
```

Parameters. The `NdbInterpretedCode` constructor takes three parameters, as described here:

- The *`table`* against which this program is to be run. Prior to NDB 8.0.18, this parameter must be supplied if the program is table-specific—that is, if it reads from or writes to columns in a table. In NDB 8.0.18 and later, the constructor accepts an `NdbRecord` in place of the `Table`

- A pointer to a *`buffer`* of 32-bit words used to store the program.

- *`buffer_word_size`* is the length of the buffer passed in. If the program exceeds this length then adding new instructions will fail with error `4518 Too many instructions in interpreted program`.

  Alternatively, if no buffer is passed, a buffer will be dynamically allocated internally and extended to cope as instructions are added.

Return value. An instance of `NdbInterpretedCode`.

2.3.24.3 NdbInterpretedCode::add_reg()

Description. This method sums the values stored in any two given registers and stores the result in a third register.

Signature.

```
int add_reg
    (
      Uint32 RegDest,
      Uint32 RegSource1,
      Uint32 RegSource2
    )
```

Parameters. This method takes three parameters. The first of these is the register in which the result is to be stored (*`RegDest`*). The second and third parameters (*`RegSource1`* and *`RegSource2`*) are the registers whose values are to be summed.

Note

It is possible to re-use for storing the result one of the registers whose values are summed; that is, *`RegDest`* can be the same as *`RegSource1`* or *`RegSource2`*.

Return value. Returns `0` on success, `-1` on failure.

2.3.24.4 NdbInterpretedCode::add_val()

Description. This method adds a specified value to the value of a given table column, and places the original and modified column values in registers 6 and 7. It is equivalent to the following series of `NdbInterpretedCode` method calls, where *`attrId`* is the table column' attribute ID and *`aValue`* is the value to be added:

```
read_attr(6, attrId);
load_const_u32(7, aValue);
add_reg(7,6,7);
write_attr(attrId, 7);
```

aValue can be a 32-bit or 64-bit integer.

Signature. This method can be invoked in either of two ways, depending on whether *aValue* is 32-bit or 64-bit.

32-bit *aValue*:

```
int add_val
    (
      Uint32 attrId,
      Uint32 aValue
    )
```

64-bit *aValue*:

```
int add_val
    (
      Uint32 attrId,
      Uint64 aValue
    )
```

Parameters. A table column attribute ID and a 32-bit or 64-bit integer value to be added to this column value.

Return value. Returns `0` on success, `-1` on failure.

2.3.24.5 NdbInterpretedCode::branch_col_and_mask_eq_mask()

Description. This method is used to compare a `BIT` column value with a bitmask; if the column value `AND`ed together with the bitmask is equal to the bitmask, then execution jumps to a specified label specified in the method call.

Signature.

```
int branch_col_and_mask_eq_mask
    (
      const void* mask,
      Uint32 unused,
      Uint32 attrId,
      Uint32 Label
    )
```

Parameters. This method can accept four parameters, of which three are actually used. These are described in the following list:

- A pointer to a constant *mask* to compare the column value to
- A `Uint32` value which is currently *unused*.
- The *attrId* of the column to be compared.
- A program *Label* to jump to if the condition is true.

Return value. This method returns `0` on success and `-1` on failure.

2.3.24.6 NdbInterpretedCode::branch_col_and_mask_eq_zero()

Description. This method is used to compare a `BIT` column value with a bitmask; if the column value `AND`ed together with the bitmask is equal to `0`, then execution jumps to a specified label specified in the method call.

Signature.

```
int branch_col_and_mask_eq_zero
    (
      const void* mask,
      Uint32 unused,
      Uint32 attrId,
      Uint32 Label
    )
```

Parameters. This method can accept the following four parameters, of which three are actually used:

- A pointer to a constant `mask` to compare the column value to.
- A `Uint32` value which is currently `unused`.
- The `attrId` of the column to be compared.
- A program `Label` to jump to if the condition is true.

Return value. This method returns `0` on success and `-1` on failure.

2.3.24.7 NdbInterpretedCode::branch_col_and_mask_ne_mask()

Description. This method is used to compare a `BIT` column value with a bitmask; if the column value `AND`ed together with the bitmask is not equal to the bitmask, then execution jumps to a specified label specified in the method call.

Signature.

```
int branch_col_and_mask_ne_mask
    (
      const void* mask,
      Uint32 unused,
      Uint32 attrId,
      Uint32 Label
    )
```

Parameters. This method accepts four parameters, of which three are actually used. These described in the following list:

- A pointer to a constant `mask` to compare the column value to.
- A `Uint32` value which is currently `unused`.
- The `attrId` of the column to be compared.
- A program `Label` to jump to if the condition is true.

Return value. This method returns `0` on success and `-1` on failure.

2.3.24.8 NdbInterpretedCode::branch_col_and_mask_ne_zero()

Description. This method is used to compare a `BIT` column value with a bitmask; if the column value `AND`ed together with the bitmask is not equal to `0`, then execution jumps to a specified label specified in the method call.

Signature.

```
int branch_col_and_mask_ne_zero
    (
      const void* mask,
      Uint32 unused,
```

```
      Uint32 attrId,
      Uint32 Label
    )
```

Parameters. This method accepts the following four parameters, of which three are actually used:

- A pointer to a constant *mask* to compare the column value to.
- A Uint32 value which is currently *unused*.
- The *attrId* of the column to be compared.
- A program *Label* to jump to if the condition is true.

Return value. This method returns 0 on success and -1 on failure.

2.3.24.9 NdbInterpretedCode::branch_col_eq()

Description. This method compares a table column value with an arbitrary constant and jumps to the specified program label if the values are equal. In NDB 8.0.18 and later, it can also be used to compare two columns for equality.

Signature. Compare a column with a value:

```
int branch_col_eq
    (
      const void* val,
      Uint32 len,
      Uint32 attrId,
      Uint32 Label
    )
```

Compare two columns:

```
int branch_col_eq
    (
      Uint32 attrId1,
      Uint32 attrId2,
      Uint32 label
    )
```

Parameters. When comparing a column and a value, this method takes the following four parameters:

- A constant value (*val*)
- The length of the value (in bytes)
- The attribute ID of the table column whose value is to be compared with *val*
- A *Label* (previously defined using def_label()) to jump to if the compared values are equal

When comparing two table column values, the parameters required are shown here:

- *AttrId1*: The attribute ID of the first table column whose value is to be compared
- *AttrId2*: The attribute ID of the second table column
- *label*: Location to jump to if the compared columns are the same. Must already have been defined using def_label()

When using this method to compare two columns, the columns must be of exactly the same type.

Return value. Returns 0 on success, -1 on failure.

2.3.24.10 NdbInterpretedCode::branch_col_eq_null()

Description. This method tests the value of a table column and jumps to the indicated program label if the column value is `NULL`.

Signature.

```
int branch_col_eq_null
    (
      Uint32 attrId,
      Uint32 Label
    )
```

Parameters. This method requires the following two parameters:

- The attribute ID of the table column
- The program label to jump to if the column value is `NULL`

Return value. Returns `0` on success, `-1` on failure.

2.3.24.11 NdbInterpretedCode::branch_col_ge()

Description. This method compares a table column value with an arbitrary constant and jumps to the specified program label if the constant column value. In NDB 8.0.18 and later, it can also be used to compare two columns and perform the jump if the value of the first column is greater than or equal to that of the second.

Signature. Compare value with column:

```
int branch_col_ge
    (
      const void* val,
      Uint32 len,
      Uint32 attrId,
      Uint32 label
    )
```

Compare values of two columns:

```
int branch_col_ge
    (
      Uint32 attrId1,
      Uint32 attrId2,
      Uint32 label
    )
```

Parameters. When used to compare a value with a column, this method takes the four parameters listed here:

- A constant value (*`val`*)
- The length of the value (in bytes)
- The attribute ID of the table column whose value is to be compared with *`val`*
- A *`label`* (previously defined using `def_label()`) to jump to if the constant value is greater than or equal to the column value

The method takes the parameters listed here when used to compare two columns:

- *`AttrId1`*: The attribute ID of the first table column whose value is to be compared
- *`AttrId2`*: The attribute ID of the second table column

- *label*: Jump to this if the first column value is greater than or equal to the second

When comparing two columns, the types of the columns must be exactly the same in all respects.

Return value. Returns `0` on success, `-1` on failure.

2.3.24.12 NdbInterpretedCode::branch_col_gt()

Description. This method compares a table column value with an arbitrary constant and jumps to the specified program label if the constant is greater than the column value. In NDB 8.0.18 and later, this method is overloaded such that it can be used to compare two column values and make the jump if the first is greater than the second.

Signature. Compare value with column:

```
int branch_col_ge
    (
      const void* val,
      Uint32 len,
      Uint32 attrId,
      Uint32 label
    )
```

Compare values of two columns:

```
int branch_col_ge
    (
      Uint32 attrId1,
      Uint32 attrId2,
      Uint32 label
    )
```

Parameters. When used to compare a value with a table column, this method takes the following four parameters:

- A constant value (*val*)
- The length of the value (in bytes)
- The attribute ID of the table column whose value is to be compared with *val*
- A *Label* (previously defined using `def_label()`) to jump to if the constant value is greater than the column value

The method takes the three parameters listed here when used to compare two columns:

- *AttrId1*: The attribute ID of the first table column whose value is to be compared
- *AttrId2*: The attribute ID of the second table column
- *label*: Jump to this if the first column value is greater than or equal to the second

When comparing two columns, the types of the columns must be exactly the same in all respects.

Return value. Returns `0` on success, `-1` on failure.

2.3.24.13 NdbInterpretedCode::branch_col_le()

Description. This method compares a table column value with an arbitrary constant and jumps to the specified program label if the constant is less than or equal to the column value. Beginning with NDB 8.0.18, it can also be used to compare two table column values in this fashion.

Signature. Compare a table column value with a constant:

```
int branch_col_le
    (
      const void* val,
      Uint32 len,
      Uint32 attrId,
      Uint32 Label
    )
```

Compare values of two table columns:

```
int branch_col_ge
    (
      Uint32 attrId1,
      Uint32 attrId2,
      Uint32 label
    )
```

Parameters. When comparing a table column value with a constant, this method takes the four parameters listed here:

- A constant value (`val`)
- The length of the value (in bytes)
- The attribute ID of the table column whose value is to be compared with `val`
- A `Label` (previously defined using `def_label()`) to jump to if the constant value is less than or equal to the column value

The method takes the three parameters listed here when used to compare two table column values:

- `AttrId1`: The attribute ID of the first table column whose value is to be compared
- `AttrId2`: The attribute ID of the second table column
- `label`: Jump to this if the first column value is less than or equal to the second

When comparing two table column values, the types of the column values must be exactly the same in all respects.

Return value. Returns `0` on success, `-1` on failure.

2.3.24.14 NdbInterpretedCode::branch_col_like()

Description. This method tests a table column value against a regular expression pattern and jumps to the indicated program label if they match.

Signature.

```
int branch_col_like
    (
      const void* val,
      Uint32 len,
      Uint32 attrId,
      Uint32 Label
    )
```

Parameters. This method takes four parameters, which are listed here:

- A regular expression pattern (`val`); see Pattern-Based NdbInterpretedCode Branch Operations, for the syntax supported
- Length of the pattern (in bytes)
- The attribute ID for the table column being tested

- The program label to jump to if the table column value matches the pattern

Return value. `0` on success, `-1` on failure

2.3.24.15 NdbInterpretedCode::branch_col_lt()

Description. This method compares a table column value with an arbitrary constant and jumps to the specified program label if the constant is less than the column value. In NDB 8.0.18 and later, two table column values can be compared instead.

Signature. Compare a table column value with a constant:

```
int branch_col_lt
    (
      const void* val,
      Uint32 len,
      Uint32 attrId,
      Uint32 Label
    )
```

Compare two table column values:

```
int branch_col_lt
    (
      Uint32 attrId1,
      Uint32 attrId2,
      Uint32 label
    )
```

Parameters. When comparing a table column value with a constant, this method takes the following four parameters:

- A constant value (*`val`*)
- The length of the value (in bytes)
- The attribute ID of the table column whose value is to be compared with *`val`*
- A *`Label`* (previously defined using `def_label()`) to jump to if the constant value is less than the column value

When used to compare two table column values, `branch_col_lt()` takes the folowwing three parameters:

- *`AttrId1`*: The attribute ID of the first table column whose value is to be compared
- *`AttrId2`*: The attribute ID of the second table column
- *`label`*: Jump to this if the first column value is less than the second

When comparing two table column values, the types of the table column values must be exactly the same. This means that they must have the same length, precision, and scale.

Return value. `0` on success, `-1` on failure.

2.3.24.16 NdbInterpretedCode::branch_col_ne()

Description. This method compares a table column value with an arbitrary constant and jumps to the specified program label if the two values are not equal. In NDB 8.0.18 and later, it can also be used to compare a table column value with another table column value instead.

Signature. Compare a table column value with a constant:

```
int branch_col_ne
    (
      const void* val,
      Uint32 len,
      Uint32 attrId,
      Uint32 Label
    )
```

Compare two table column values:

```
int branch_col_ne
    (
      Uint32 attrId1,
      Uint32 attrId2,
      Uint32 label
    )
```

Parameters. When comparing a table column value with a constant, this method takes the four parameters listed here:

- A constant value (*`val`*)
- The length of the value (in bytes)
- The attribute ID of the table column whose value is to be compared with *`val`*
- A *`Label`* (previously defined using `def_label()`) to jump to if the compared values are unequal

When comparing two table column values, the parameters required are shown here:

- *`AttrId1`*: The attribute ID of the first table column whose value is to be compared
- *`AttrId2`*: The attribute ID of the second table column
- *`label`*: Location to jump to if the compared columns are not the same. Must already have been defined using `def_label()`

When using this method to compare two table column values, the columns must be of exactly the same type.

Return value. Returns `0` on success, `-1` on failure.

2.3.24.17 NdbInterpretedCode::branch_col_ne_null()

Description. This method tests the value of a table column and jumps to the indicated program label if the column value is not `NULL`.

Signature.

```
int branch_col_ne_null
    (
      Uint32 attrId,
      Uint32 Label
    )
```

Parameters. This method requires the following two parameters:

- The attribute ID of the table column
- The program label to jump to if the column value is not `NULL`

Return value. Returns `0` on success, `-1` on failure.

2.3.24.18 NdbInterpretedCode::branch_col_notlike()

Description. This method is similar to `branch_col_like()` in that it tests a table column value against a regular expression pattern; however it jumps to the indicated program label only if the pattern and the column value do *not* match.

Signature.

```
int branch_col_notlike
    (
      const void* val,
      Uint32 len,
      Uint32 attrId,
      Uint32 Label
    )
```

Parameters. This method takes the following four parameters:

- A regular expression pattern (*`val`*); see Pattern-Based NdbInterpretedCode Branch Operations, for the syntax supported
- Length of the pattern (in bytes)
- The attribute ID for the table column being tested
- The program label to jump to if the table column value does not match the pattern

Return value. Returns `0` on success, `-1` on failure

2.3.24.19 NdbInterpretedCode::branch_eq()

Description. This method compares two register values; if they equal, then the interpreted program jumps to the specified label.

Signature.

```
int branch_eq
    (
      Uint32 RegLvalue,
      Uint32 RegRvalue,
      Uint32 Label
    )
```

Parameters. This method takes three parameters, the registers whose values are to be compared—*`RegLvalue`* and *`RegRvalue`*—and the program *`Label`* to jump to if they are equal. *`Label`* must have been defined previously using `def_label()` (see Section 2.3.24.30, “NdbInterpretedCode::def_label()”).

Return value. `0` on success, `-1` on failure.

2.3.24.20 NdbInterpretedCode::branch_eq_null()

Description. This method compares a register value with `NULL`; if the register value is null, then the interpreted program jumps to the specified label.

Signature.

```
int branch_eq_null
    (
      Uint32 RegLvalue,
      Uint32 Label
    )
```

Parameters. This method takes two parameters, the register whose value is to be compared with `NULL` (*`RegLvalue`*) and the program *`Label`* to jump to if *`RegLvalue`* is null. *`Label`* must have been defined previously using `def_label()` (see Section 2.3.24.30, “NdbInterpretedCode::def_label()”).

Return value. `0` on success, `-1` on failure.

2.3.24.21 NdbInterpretedCode::branch_ge()

Description. This method compares two register values; if the first is greater than or equal to the second, the interpreted program jumps to the specified label.

Signature.

```
int branch_ge
    (
      Uint32 RegLvalue,
      Uint32 RegRvalue,
      Uint32 Label
    )
```

Parameters. This method takes three parameters, the registers whose values are to be compared—*`RegLvalue`* and *`RegRvalue`*—and the program *`Label`* to jump to if *`RegLvalue`* is greater than or equal to *`RegRvalue`*. *`Label`* must have been defined previously using `def_label()` (see Section 2.3.24.30, “NdbInterpretedCode::def_label()”).

Return value. `0` on success, `-1` on failure.

2.3.24.22 NdbInterpretedCode::branch_gt()

Description. This method compares two register values; if the first is greater than the second, the interpreted program jumps to the specified label.

Signature.

```
int branch_gt
    (
      Uint32 RegLvalue,
      Uint32 RegRvalue,
      Uint32 Label
    )
```

Parameters. This method takes three parameters, the registers whose values are to be compared—*`RegLvalue`* and *`RegRvalue`*—and the program *`Label`* to jump to if *`RegLvalue`* is greater than *`RegRvalue`*. *`Label`* must have been defined previously using `def_label()` (see Section 2.3.24.30, “NdbInterpretedCode::def_label()”).

Return value. `0` on success, `-1` on failure.

2.3.24.23 NdbInterpretedCode::branch_label()

Description. This method performs an unconditional jump to an interpreted program label (see Section 2.3.24.30, “NdbInterpretedCode::def_label()”).

Signature.

```
int branch_label
    (
      Uint32 Label
    )
```

Parameters. This method takes a single parameter, an interpreted program *`Label`* defined using `def_label()`.

Return value. `0` on success, `-1` on failure.

2.3.24.24 NdbInterpretedCode::branch_le()

Description. This method compares two register values; if the first is less than or equal to the second, the interpreted program jumps to the specified label.

Signature.

```
int branch_le
    (
      Uint32 RegLvalue,
      Uint32 RegRvalue,
      Uint32 Label
    )
```

Parameters. This method takes three parameters, the registers whose values are to be compared —*RegLvalue* and *RegRvalue*—and the program *Label* to jump to if *RegLvalue* is less than or equal to *RegRvalue*. *Label* must have been defined previously using `def_label()` (see Section 2.3.24.30, “NdbInterpretedCode::def_label()”).

Return value. `0` on success, `-1` on failure.

2.3.24.25 NdbInterpretedCode::branch_lt()

Description. This method compares two register values; if the first is less than the second, the interpreted program jumps to the specified label.

Signature.

```
int branch_lt
    (
      Uint32 RegLvalue,
      Uint32 RegRvalue,
      Uint32 Label
    )
```

Parameters. This method takes three parameters, the registers whose values are to be compared —*RegLvalue* and *RegRvalue*—and the program *Label* to jump to if *RegLvalue* is less than *RegRvalue*. *Label* must have been defined previously using `def_label()` (see Section 2.3.24.30, “NdbInterpretedCode::def_label()”).

Return value. `0` on success, `-1` on failure.

2.3.24.26 NdbInterpretedCode::branch_ne()

Description. This method compares two register values; if they are not equal, then the interpreted program jumps to the specified label.

Signature.

```
int branch_ne
    (
      Uint32 RegLvalue,
      Uint32 RegRvalue,
      Uint32 Label
    )
```

Parameters. This method takes three parameters, the registers whose values are to be compared (*RegLvalue* and *RegRvalue*) and the program label to jump to if they are not equal. *Label* must have been defined previously using `def_label()`.

Return value. `0` on success, `-1` on failure.

2.3.24.27 NdbInterpretedCode::branch_ne_null()

Description. This method compares a register value with `NULL`; if the value is not null, then the interpreted program jumps to the specified label.

Signature.

```
int branch_ne_null
    (
      Uint32 RegLvalue,
      Uint32 Label
    )
```

Parameters. This method takes two parameters, the register whose value is to be compared with `NULL` (*`RegLvalue`*) and the program *`Label`* to jump to if *`RegLvalue`* is not null. *`Label`* must have been defined previously using `def_label()` (see Section 2.3.24.30, "NdbInterpretedCode::def_label()").

Return value. `0` on success, `-1` on failure.

2.3.24.28 NdbInterpretedCode::call_sub()

Description. This method is used to call a subroutine.

Signature.

```
int call_sub
    (
      Uint32 SubroutineNumber
    )
```

Parameters. This method takes a single parameter, the number identifying the subroutine to be called.

Return value. Returns `0` on success, `-1` on failure.

2.3.24.29 NdbInterpretedCode::copy()

Description. Makes a deep copy of an `NdbInterpretedCode` object.

Signature.

```
int copy
    (
      const NdbInterpretedCode& src
    )
```

Parameters. A reference to the copy.

Return value. 0 on success, or an error code.

2.3.24.30 NdbInterpretedCode::def_label()

Description. This method defines a label to be used as the target of one or more jumps in an interpreted program.

`def_label()` uses a 2-word buffer and requires no space for request messages.

Signature.

```
int def_label
    (
      int LabelNum
    )
```

Parameters. This method takes a single parameter *LabelNum*, whose value must be unique among all values used for labels within the interpreted program.

Return value. 0 on success; -1 on failure.

2.3.24.31 NdbInterpretedCode::def_sub()

Description. This method is used to mark the start of a subroutine. See Using Subroutines with NdbInterpretedCode, for more information.

Signature.

```
int def_sub
    (
      Uint32 SubroutineNumber
    )
```

Parameters. A single parameter, a number used to identify the subroutine.

Return value. Returns 0 on success, -1 otherwise.

2.3.24.32 NdbInterpretedCode::finalise()

Description. This method prepares an interpreted program, including any subroutines it might have, by resolving all branching instructions and calls to subroutines. It must be called before using the program, and can be invoked only once for any given NdbInterpretedCode object.

If no instructions have been defined, this method attempts to insert a single interpret_exit_ok() method call prior to finalization.

Signature.

```
int finalise
    (
      void
    )
```

Parameters. *None*.

Return value. Returns 0 on success, -1 otherwise.

2.3.24.33 NdbInterpretedCode::getNdbError()

Description. This method returns the most recent error associated with this NdbInterpretedCode object.

Signature.

```
const class NdbError& getNdbError
    (
      void
    ) const
```

Parameters. *None*.

Return value. A reference to an NdbError object.

2.3.24.34 NdbInterpretedCode::getTable()

Description. This method can be used to obtain a reference to the table for which the NdbInterpretedCode object was defined.

Signature.

```
const NdbDictionary::Table* getTable
    (
      void
    ) const
```

Parameters. *None*.

Return value. A pointer to a `Table` object. Returns `NULL` if no table object was supplied when the `NdbInterpretedCode` was instantiated.

2.3.24.35 NdbInterpretedCode::getWordsUsed()

Description. This method returns the number of words from the buffer that have been used, whether the buffer is one that is user-supplied or the internally-provided buffer.

Signature.

```
Uint32 getWordsUsed
    (
      void
    ) const
```

Parameters. *None*.

Return value. The 32-bit number of words used from the buffer.

2.3.24.36 NdbInterpretedCode::interpret_exit_last_row()

Description. For a scanning operation, invoking this method indicates that this row should be returned as part of the scan, and that no more rows in this fragment should be scanned. For other types of operations, the method causes the operation to be aborted.

Signature.

```
int interpret_exit_last_row
    (
      void
    )
```

Parameters. *None*.

Return value. Returns `0` if successful, `-1` otherwise.

2.3.24.37 NdbInterpretedCode::interpret_exit_nok()

Description. For scanning operations, this method is used to indicate that the current row should not be returned as part of the scan, and to cause the program should move on to the next row. It causes other types of operations to be aborted.

Signature.

```
int interpret_exit_nok
    (
      Uint32 ErrorCode = 626 //  HA_ERR_KEY_NOT_FOUND
    )
```

Parameters. This method takes a single (optional) parameter *`ErrorCode`* which . For a complete listing of NDB error codes, see Section 2.4.2, "NDB Error Codes: by Type". If not supplied, defaults to 626 (**`HA_ERR_KEY_NOT_FOUND`**/`Tuple did not exist`. Applications should use error code 626 or another code in the range 6000 to 6999 inclusive.

For any values other than those mentioned here, the behavior of this method is undefined, and is subject to change at any time without prior notice.

Return value. Returns `0` on success, `-1` on failure.

2.3.24.38 NdbInterpretedCode::interpret_exit_ok()

Description. For a scanning operation, this method indicates that the current row should be returned as part of the results of the scan and that the program should move on to the next row. For other operations, calling this method causes the interpreted program to exit.

Signature.

```
int interpret_exit_ok
    (
      void
    )
```

Parameters. *None*.

Return value. Returns `0` on success, `-1` on failure.

2.3.24.39 NdbInterpretedCode::load_const_null()

Description. This method is used to load a `NULL` value into a register.

Signature.

```
int load_const_null
    (
      Uint32 RegDest
    )
```

Parameters. This method takes a single parameter, the register into which to place the `NULL`.

Return value. Returns `0` on success, `-1` otherwise.

2.3.24.40 NdbInterpretedCode::load_const_u16()

Description. This method loads a 16-bit value into the specified interpreter register.

Signature.

```
int load_const_u16
    (
      Uint32 RegDest,
      Uint32 Constant
    )
```

Parameters. This method takes the following two parameters:

- *`RegDest`*: The register into which the value should be loaded.
- A *`Constant`* value to be loaded

Return value. Returns `0` on success, `-1` otherwise.

2.3.24.41 NdbInterpretedCode::load_const_u32()

Description. This method loads a 32-bit value into the specified interpreter register.

Signature.

```
int load_const_u32
    (
      Uint32 RegDest,
      Uint32 Constant
    )
```

Parameters. This method takes the following two parameters:

- *RegDest*: The register into which the value should be loaded.
- A *Constant* value to be loaded

Return value. Returns 0 on success, -1 otherwise.

2.3.24.42 NdbInterpretedCode::load_const_u64()

Description. This method loads a 64-bit value into the specified interpreter register.

Signature.

```
int load_const_u64
    (
      Uint32 RegDest,
      Uint64 Constant
    )
```

Parameters. This method takes the following two parameters:

- *RegDest*: The register into which the value should be loaded.
- A *Constant* value to be loaded

Return value. Returns 0 on success, -1 otherwise.

2.3.24.43 NdbInterpretedCode::read_attr()

Description. The read_attr() method is used to read a table column value into a program register. The column may be specified either by using its attribute ID or as a pointer to a Column object.

Signature. This method can be called in either of two ways. The first of these is by referencing the column by its attribute ID, as shown here:

```
int read_attr
    (
      Uint32 RegDest,
      Uint32 attrId
    )
```

Alternatively, you can reference the column as a Column object, as shown here:

```
int read_attr
    (
      Uint32 RegDest,
      const NdbDictionary::Column* column
    )
```

Parameters. This method takes two parameters, as described here:

- The register to which the column value is to be copied (*RegDest*).
- Either of the following references to the table column whose value is to be copied:
  - The table column's attribute ID (*attrId*)

- A pointer to a *column*—that is, a pointer to an `Column` object referencing the table column

Return value. Returns `0` on success, and `-1` on failure.

2.3.24.44 NdbInterpretedCode::ret_sub()

Description. This method marks the end of the current subroutine.

Signature.

```
int ret_sub
    (
      void
    )
```

Parameters. *None*.

Return value. Returns `0` on success, `-1` otherwise.

2.3.24.45 NdbInterpretedCode::sub_reg()

Description. This method gets the difference between the values stored in any two given registers and stores the result in a third register.

Signature.

```
int sub_reg
    (
      Uint32 RegDest,
      Uint32 RegSource1,
      Uint32 RegSource2
    )
```

Parameters. This method takes three parameters. The first of these is the register in which the result is to be stored (*RegDest*). The second and third parameters (*RegSource1*and *RegSource2*) are the registers whose values are to be subtracted. In other words, the value of register *RegDest* is calculated as the value of the expression shown here:

```
(value in register RegSource1) − (value in register RegSource2)
```

Note

It is possible to re-use one of the registers whose values are subtracted for storing the result; that is, *RegDest* can be the same as *RegSource1* or *RegSource2*.

Return value. `0` on success; `-1` on failure.

2.3.24.46 NdbInterpretedCode::sub_val()

Description. This method subtracts a specified value from the value of a given table column, and places the original and modified column values in registers 6 and 7. It is equivalent to the following series of `NdbInterpretedCode` method calls, where *attrId* is the table column' attribute ID and *aValue* is the value to be subtracted:

```
read_attr(6, attrId);
load_const_u32(7, aValue);
sub_reg(7,6,7);
write_attr(attrId, 7);
```

aValue can be a 32-bit or 64-bit integer.

Signature. This method can be invoked in either of two ways, depending on whether *aValue* is 32-bit or 64-bit.

32-bit *aValue*:

```
int sub_val
    (
      Uint32 attrId,
      Uint32 aValue
    )
```

64-bit *aValue*:

```
int sub_val
    (
      Uint32 attrId,
      Uint64 aValue
    )
```

Parameters. A table column attribute ID and a 32-bit or 64-bit integer value to be subtracted from this column value.

Return value. Returns `0` on success, `-1` on failure.

2.3.24.47 NdbInterpretedCode::write_attr()

Description. This method is used to copy a register value to a table column. The column may be specified either by using its attribute ID or as a pointer to a `Column` object.

Signature. This method can be invoked in either of two ways. The first of these is requires referencing the column by its attribute ID, as shown here:

```
int read_attr
    (
      Uint32 attrId,
      Uint32 RegSource
    )
```

You can also reference the column as a `Column` object instead, like this:

```
int read_attr
    (
      const NdbDictionary::Column* column,
      Uint32 RegSource
    )
```

Parameters. This method takes two parameters as follows:

- A reference to the table column to which the register value is to be copied. This can be either of the following:
  - The table column's attribute ID (*attrId*)
  - A pointer to a *column*—that is, a pointer to an `Column` object referencing the table column
- The register whose value is to be copied (*RegSource*).

Return value. Returns `0` on success; `-1` on failure.

2.3.25 The NdbOperation Class

This section discusses the `NdbOperation` class.

Parent class. *None*

Child classes. `NdbIndexOperation`, `NdbScanOperation`

Description. `NdbOperation` represents a “generic” data operation. Its subclasses represent more specific types of operations. See Section 2.3.25.18, “NdbOperation::Type” for a listing of operation types and their corresponding `NdbOperation` subclasses.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.52 NdbOperation class methods and descriptions

Name	Description
`deleteTuple()`	Removes a tuple from a table
`equal()`	Defines a search condition using equality
`getBlobHandle()`	Used to access blob attributes
`getLockHandle()`	Gets a lock handle for the operation
`getLockMode()`	Gets the operation's lock mode
`getNdbError()`	Gets the latest error
`getNdbErrorLine()`	Gets the number of the method where the latest error occurred
`getTableName()`	Gets the name of the table used for this operation
`getTable()`	Gets the table object used for this operation
`getNdbTransaction()`	Gets the `NdbTransaction` object for this operation
`getType()`	Gets the type of operation
`getValue()`	Allocates an attribute value holder for later access
`insertTuple()`	Adds a new tuple to a table
`readTuple()`	Reads a tuple from a table
`setValue()`	Defines an attribute to set or update
`updateTuple()`	Updates an existing tuple in a table
`writeTuple()`	Inserts or updates a tuple

Note

This class has no public constructor. To create an instance of `NdbOperation`, you must use `NdbTransaction::getNdbOperation()`.

Types. The `NdbOperation` class defines three public types, shown in the following table:

Table 2.53 NdbOperation class types and descriptions

Name	Description
`AbortOption()`	Determines whether a failed operation causes failure of the transaction of which it is part
`LockMode()`	The type of lock used when performing a read operation
`Type()`	Operation access types

Note

For more information about the use of `NdbOperation`, see Single-row operations.

2.3.25.1 NdbOperation::AbortOption

Description. This type is used to determine whether failed operations should force a transaction to be aborted. It is used as an argument to the `execute()` method—see Section 2.3.30.6, "NdbTransaction::execute()", for more information.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.54 NdbOperation::AbortOption type values and descriptions

Name	Description
`AbortOnError`	A failed operation causes the transaction to abort.
`AO_IgnoreOnError`	Failed operations are ignored; the transaction continues to execute.
`DefaultAbortOption`	The `AbortOption` value is set according to the operation type: • Read operations: `AO_IgnoreOnError` • Scan takeover or DML operations: `AbortOnError`

See Section 2.3.30.6, "NdbTransaction::execute()", for more information.

2.3.25.2 NdbOperation::deleteTuple()

Description. This method defines the `NdbOperation` as a `DELETE` operation. When the `NdbTransaction::execute()` method is invoked, the operation deletes a tuple from the table.

Signature.

```
virtual int deleteTuple
    (
      void
    )
```

Parameters. *None*.

Return value. Returns `0` on success, `-1` on failure.

2.3.25.3 NdbOperation::equal()

Description. This method defines a search condition with an equality. The condition is true if the attribute has the given value. To set search conditions on multiple attributes, use several calls to `equal()`; in such cases all of them must be satisfied for the tuple to be selected.

> **Important**
>
> If the attribute is of a fixed size, its value must include all bytes. In particular a `Char` value must be native-space padded. If the attribute is of variable size, its value must start with 1 or 2 little-endian length bytes (2 if its type is `Long*`).

> **Note**
>
> When using `insertTuple()`, you may also define the search key with `setValue()`. See Section 2.3.25.17, "NdbOperation::setValue()".

Signature. There are 10 versions of `equal()`, each having slightly different parameters. All of these are listed here:

```
int  equal
```

```
    (
      const char* name,
      const char* value
    )

int  equal
    (
      const char* name,
      Int32       value
    )

int  equal
    (
      const char* name,
      Uint32      value
    )

int  equal
    (
      const char* name,
      Int64       value
    )

int  equal
    (
      const char* name,
      Uint64      value
    )

int  equal
    (
      Uint32      id,
      const char* value
    )

int  equal
    (
      Uint32 id,
      Int32  value
    )

int  equal
    (
      Uint32 id,
      Uint32 value
    )

int  equal
    (
      Uint32 id,
      Int64  value
    )

int  equal
    (
      Uint32 id,
      Uint64 value
    )
```

Parameters. This method requires two parameters:

- The first parameter can be either of the following:

  1. The *name* of the attribute (a string)

  2. The *id* of the attribute (an unsigned 32-bit integer)

- The second parameter is the attribute *value* to be tested. This value can be any one of the following 5 types:

  1. String

2. 32-bit integer
3. Unsigned 32-bit integer
4. 64-bit integer
5. Unsigned 64-bit integer

Return value. Returns `-1` in the event of an error.

2.3.25.4 NdbOperation::getBlobHandle()

Description. This method is used in place of `getValue()` or `setValue()` for blob attributes. It creates a blob handle (`NdbBlob` object). A second call with the same argument returns the previously created handle. The handle is linked to the operation and is maintained automatically.

Signature. This method has two forms, depending on whether it is called with the name or the ID of the blob attribute:

```
virtual NdbBlob* getBlobHandle
    (
      const char* name
    )
```

or

```
virtual NdbBlob* getBlobHandle
    (
      Uint32 id
    )
```

Parameters. This method takes a single parameter, which can be either one of the following:

- The *`name`* of the attribute
- The *`id`* of the attribute

Return value. Regardless of parameter type used, this method return a pointer to an instance of `NdbBlob`.

2.3.25.5 NdbOperation::getLockHandle

Description. Returns a pointer to the current operation's lock handle. When used with `NdbRecord`, the lock handle must first be requested with the `OO_LOCKHANDLE` operation option. For other operations, this method can be used alone. In any case, the `NdbLockHandle` object returned by this method cannot be used until the operation has been executed.

Using lock handle methods. Shared or exclusive locks taken by read operations in a transaction are normally held until the transaction commits or aborts. Such locks can be released before a transaction commits or aborts by requesting a lock handle when defining the read operation. Once the read operation has been executed, an `NdbLockHandle` can be used to create a new unlock operation (with `NdbTransaction::unlock()`). When the unlock operation is executed, the row lock placed by the read operation is released.

The steps required to release these locks are listed here:

- Define the primary key read operation in the normal way with lock mode `LM_Read` or `LM_Exclusive`.
- Call `NdbOperation::getLockHandle()` during operation definition, or, for `Ndbrecord`, set the `OO_LOCKHANDLE` operation option when calling `NdbTransaction::readTuple()`.

- Call `NdbTransaction::execute()`; the row is now locked from this point on, as normal.
- (Use data, possibly making calls to `NdbTransaction::execute()`.)
- Call `NdbTransaction::unlock()`, passing in the `const NdbLockHandle` obtained previously to create an unlock operation.
- Call `NdbTransaction::execute()`; this unlocks the row.

Notes:

- As with other operation types, unlock operations can be batched.
- Each `NdbLockHandle` object refers to a lock placed on a row by a single primary key read operation. A single row in the database may have concurrent multiple lock holders (mode `LM_Read`) and may have multiple lock holders pending (`LM_Exclusive`), so releasing the claim of one lock holder may not result in a change to the observable lock status of the row.
- Lock handles are supported for scan lock takeover operations; the lock handle must be requested before the lock takeover is executed.
- Lock handles and unlock operations are not supported for unique index read operations.

Signature.

```
const NdbLockHandle* getLockHandle
    (
      void
    ) const
```

(or)

```
const NdbLockHandle* getLockHandle
    (
      void
    )
```

Parameters. *None*.

Return value. Pointer to an `NdbLockHandle` that can be used by the `NdbTransaction` methods `unlock()` and `releaseLockHandle()`.

2.3.25.6 NdbOperation::getLockMode()

Description. This method gets the operation's lock mode.

Signature.

```
LockMode getLockMode
    (
      void
    ) const
```

Parameters. *None*.

Return value. A `LockMode` value. See Section 2.3.25.15, "NdbOperation::LockMode".

2.3.25.7 NdbOperation::getNdbError()

Description. This method gets the most recent error (an `NdbError` object).

Signature.

```
const NdbError& getNdbError
    (
      void
    ) const
```

Parameters. *None*.

Return value. An `NdbError` object.

2.3.25.8 NdbOperation::getNdbErrorLine()

Description. This method retrieves the method number in which the latest error occurred.

Signature. This method can and should be used as shown here:

```
int getNdbErrorLine
    (
      void
    ) const
```

Parameters. *None*.

Return value. The method number (an integer).

2.3.25.9 NdbOperation::getTable()

Description. This method is used to retrieve the table object associated with the operation.

Signature.

```
const NdbDictionary::Table* getTable
    (
      void
    ) const
```

Parameters. *None*.

Return value. A pointer to an instance of `Table`.

2.3.25.10 NdbOperation::getTableName()

Description. This method retrieves the name of the table used for the operation.

Signature.

```
const char* getTableName
    (
      void
    ) const
```

Parameters. *None*.

Return value. The name of the table.

2.3.25.11 NdbOperation::getNdbTransaction()

Description. Gets the `NdbTransaction` object for this operation.

Signature.

```
virtual NdbTransaction* getNdbTransaction
```

```
    (
      void
    ) const
```

Parameters. *None*.

Return value. A pointer to an `NdbTransaction` object.

2.3.25.12 NdbOperation::getType()

Description. This method is used to retrieve the access type for this operation.

Signature.

```
Type getType
    (
      void
    ) const
```

Parameters. *None*.

Return value. A `Type` value.

2.3.25.13 NdbOperation::getValue()

Description. This method prepares for the retrieval of an attribute value. The NDB API allocates memory for an `NdbRecAttr` object that is later used to obtain the attribute value. This can be done by using one of the many `NdbRecAttr` accessor methods, the exact method to be used depending on the attribute's data type. (This includes the generic `NdbRecAttr::aRef()` method, which retrieves the data as `char*`, regardless of its actual type. However, this is not type-safe, and requires a cast from the user.)

> **Important**
>
> This method does *not* fetch the attribute value from the database; the `NdbRecAttr` object returned by this method is not readable or printable before calling `NdbTransaction::execute()`.
>
> If a specific attribute has not changed, the corresponding `NdbRecAttr` has the state `UNDEFINED`. This can be checked by using `NdbRecAttr::isNULL()`, which in such cases returns `-1`.
>
> See Section 2.3.30.6, “NdbTransaction::execute()”, and Section 2.3.26.13, “NdbRecAttr::isNULL()”.

Signature. There are three versions of this method, each having different parameters:

```
NdbRecAttr* getValue
    (
      const char* name,
      char*       value = 0
    )

NdbRecAttr* getValue
    (
      Uint32 id,
      char*  value = 0
    )

NdbRecAttr* getValue
    (
      const NdbDictionary::Column* col,
      char*                        value = 0
```

```
    )
```

Parameters. All three forms of this method have two parameters, the second parameter being optional (defaults to `0`). They differ only with regard to the type of the first parameter, which can be any one of the following:

- The attribute *`name`*
- The attribute *`id`*
- The table *`column`* on which the attribute is defined

In all three cases, the second parameter is a character buffer in which a non-`NULL` attribute value is returned. In the event that the attribute is `NULL`, is it stored only in the `NdbRecAttr` object returned by this method.

If no *`value`* is specified in the `getValue()` method call, or if 0 is passed as the value, then the `NdbRecAttr` object provides memory management for storing the received data. If the maximum size of the received data is above a small fixed size, `malloc()` is used to store it: For small sizes, a small, fixed internal buffer (32 bytes in extent) is provided. This storage is managed by the `NdbRecAttr` instance; it is freed when the operation is released, such as at transaction close time; any data written here that you wish to preserve should be copied elsewhere before this freeing of memory takes place.

If you pass a non-zero pointer for *`value`*, then it is assumed that this points to an portion of memory which is large enough to hold the maximum value of the column; any returned data is written to that location. The pointer should be at least 32-bit aligned.

Note

Index columns cannot be used in place of table columns with this method. In cases where a table column is not available, you can use the attribute name, obtained with `getName()`, for this purpose instead.

Return value. A pointer to an `NdbRecAttr` object to hold the value of the attribute, or a `NULL` pointer, indicating an error.

Retrieving integers. Integer values can be retrieved from both the *`value`* buffer passed as this method's second parameter, and from the `NdbRecAttr` object itself. On the other hand, character data is available from `NdbRecAttr` if no buffer has been passed in to `getValue()` (see Section 2.3.26.2, “NdbRecAttr::aRef()”). However, character data is written to the buffer only if one is provided, in which case it cannot be retrieved from the `NdbRecAttr` object that was returned. In the latter case, `NdbRecAttr::aRef()` returns a buffer pointing to an empty string.

Accessing bit values. The following example shows how to check a given bit from the *`value`* buffer. Here, `op` is an operation (`NdbOperation` object), `name` is the name of the column from which to get the bit value, and `trans` is an `NdbTransaction` object:

```
Uint32 buf[];

op->getValue(name, buf); /* bit column */

trans->execute();

if(buf[X/32] & 1 << (X & 31)) /* check bit X */
{
  /* bit X set */
}
```

2.3.25.14 NdbOperation::insertTuple()

Description. This method defines the `NdbOperation` to be an `INSERT` operation. When the `NdbTransaction::execute()` method is called, this operation adds a new tuple to the table.

Signature.

```
virtual int insertTuple
    (
      void
    )
```

Parameters. *None*.

Return value. Returns `0` on success, `-1` on failure.

2.3.25.15 NdbOperation::LockMode

Description. This type describes the lock mode used when performing a read operation.

Enumeration values. Possible values for this type are shown, along with descriptions, in the following table:

Table 2.55 NdbOperation::LockMode type values and descriptions

Name	Description
`LM_Read`	Read with shared lock
`LM_Exclusive`	Read with exclusive lock
`LM_CommittedRead`	Ignore locks; read last committed
`LM_SimpleRead`	Read with shared lock, but release lock directly

Note

There is also support for dirty reads (`LM_Dirty`), but this is normally for internal purposes only, and should not be used for applications deployed in a production setting.

2.3.25.16 NdbOperation::readTuple()

Description. This method defines the `NdbOperation` as a `READ` operation. When the `NdbTransaction::execute()` method is invoked, the operation reads a tuple.

Signature.

```
virtual int readTuple
    (
      LockMode mode
    )
```

Parameters. *`mode`* specifies the locking mode used by the read operation. See Section 2.3.25.15, “NdbOperation::LockMode”, for possible values.

Return value. Returns `0` on success, `-1` on failure.

2.3.25.17 NdbOperation::setValue()

Description. This method defines an attribute to be set or updated.

There are a number of `NdbOperation::setValue()` methods that take a certain type as input (pass by value rather than passing a pointer). It is the responsibility of the application programmer to use the correct types.

However, the NDB API does check that the application sends a correct length to the interface as given in the length parameter. A `char*` value can contain any data type or any type of array. If the length is not provided, or if it is set to zero, then the API assumes that the pointer is correct, and does not check it.

To set a `NULL` value, use the following construct:

```
setValue("ATTR_NAME", (char*)NULL);
```

When you use `insertTuple()`, the NDB API automatically detects that it is supposed to use `equal()` instead.

In addition, it is not necessary when using `insertTuple()` to use `setValue()` on key attributes before other attributes.

Signature. There are 14 versions of `NdbOperation::setValue()`, each with slightly different parameters, as listed here (and summarized in the *Parameters* section following):

```
int setValue
    (
      const char* name,
      const char* value
)

int setValue
    (
      const char* name,
      Int32       value
    )

int setValue
    (
      const char* name,
      Uint32      value
    )

int setValue
    (
      const char* name,
      Int64       value
    )

int setValue
    (
      const char* name,
      Uint64      value
    )

int setValue
    (
      const char* name,
      float       value
    )

int setValue
    (
      const char* name,
      double      value
    )

int setValue
    (
      Uint32      id,
      const char* value
    )

int setValue
    (
      Uint32 id,
      Int32  value
    )
```

```
int setValue
    (
      Uint32 id,
      Uint32 value
    )

int setValue
    (
      Uint32 id,
      Int64  value
    )

int setValue
    (
      Uint32 id,
      Uint64 value
    )

int setValue
    (
      Uint32 id,
      float  value
    )

int setValue
    (
      Uint32 id,
      double value
    )
```

Parameters. This method requires the following two parameters:

- The first parameter identified the attribute to be set, and may be either one of the following:

  1. The attribute *`name`* (a string)

  2. The attribute *`id`* (an unsigned 32-bit integer)

- The second parameter is the *`value`* to which the attribute is to be set; its type may be any one of the following 7 types:

  1. String (`const char*`)

  2. 32-bit integer

  3. Unsigned 32-bit integer

  4. 64-bit integer

  5. Unsigned 64-bit integer

  6. Double

  7. Float

See Section 2.3.25.3, “NdbOperation::equal()”, for important information regarding the value's format and length.

Return value. Returns `-1` in the event of failure.

2.3.25.18 NdbOperation::Type

Description. `Type` is used to describe the operation access type. Each access type is supported by `NdbOperation` or one of its subclasses, as shown in the following table:

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.56 NdbOperation::Type data type values and descriptions

Name	Description
`PrimaryKeyAccess`	A read, insert, update, or delete operation using the table's pri
`UniqueIndexAccess`	A read, update, or delete operation using a unique index
`TableScan`	A full table scan
`OrderedIndexScan`	An ordered index scan

2.3.25.19 NdbOperation::writeTuple()

Description. This method defines the `NdbOperation` as a `WRITE` operation. When the `NdbTransaction::execute()` method is invoked, the operation writes a tuple to the table. If the tuple already exists, it is updated; otherwise an insert takes place.

Signature.

```
virtual int writeTuple
    (
      void
    )
```

Parameters. *None*.

Return value. Returns `0` on success, `-1` on failure.

2.3.25.20 NdbOperation::updateTuple()

Description. This method defines the `NdbOperation` as an `UPDATE` operation. When the `NdbTransaction::execute()` method is invoked, the operation updates a tuple found in the table.

Signature.

```
virtual int updateTuple
    (
      void
    )
```

Parameters. *None*.

Return value. Returns `0` on success, `-1` on failure.

2.3.26 The NdbRecAttr Class

The section describes the `NdbRecAttr` class and its public methods.

Parent class. *None*

Child classes. *None*

Description. `NdbRecAttr` contains the value of an attribute. An `NdbRecAttr` object is used to store an attribute value after it has been retrieved using the `NdbOperation::getValue()` method. This object is allocated by the NDB API. A brief example is shown here:

```
MyRecAttr = MyOperation->getValue("ATTR2", NULL);

if(MyRecAttr == NULL)
  goto error;

if(MyTransaction->execute(Commit) == -1)
  goto error;
```

```
ndbout << MyRecAttr->u_32_value();
```

For additional examples, see Section 2.5.1, "NDB API Example Using Synchronous Transactions".

Note

An `NdbRecAttr` object is instantiated with its value only when `NdbTransaction::execute()` is invoked. Prior to this, the value is undefined. (Use `NdbRecAttr::isNULL()` to check whether the value is defined.) This means that an `NdbRecAttr` object has valid information only between the times that `NdbTransaction::execute()` and `Ndb::closeTransaction()` are called. The value of the `NULL` indicator is `-1` until the `NdbTransaction::execute()` method is invoked.

Methods. `NdbRecAttr` has a number of methods for retrieving values of various simple types directly from an instance of this class.

Note

It is also possible to obtain a reference to the value regardless of its actual type, by using `NdbRecAttr::aRef()`; however, you should be aware that this is not type-safe, and requires a cast from the user.

The following table lists all of the public methods of this class and the purpose or use of each method:

Table 2.57 NdbRecAttr class methods and descriptions

Name	Description
`~NdbRecAttr()`	Destructor method
`aRef()`	Gets a pointer to the attribute value
`char_value()`	Retrieves a `Char` attribute value
`clone()`	Makes a deep copy of the `RecAttr` object
`double_value()`	Retrieves a `Double` attribute value, as a double (8 bytes)
`float_value()`	Retrieves a `Float` attribute value, as a float (4 bytes)
`get_size_in_bytes()`	Gets the size of the attribute, in bytes
`getColumn()`	Gets the column to which the attribute belongs
`getType()`	Gets the attribute's type (`Column::Type`)
`isNULL()`	Tests whether the attribute is `NULL`
`int8_value()`	Retrieves a `Tinyint` attribute value, as an 8-bit integer
`int32_value()`	Retrieves an `Int` attribute value, as a 32-bit integer
`int64_value()`	Retrieves a `Bigint` attribute value, as a 64-bit integer
`medium_value()`	Retrieves a `Mediumint` attribute value, as a 32-bit integer
`short_value()`	Retrieves a `Smallint` attribute value, as a 16-bit integer
`u_8_value()`	Retrieves a `Tinyunsigned` attribute value, as an unsigned 8-bit integer
`u_32_value()`	Retrieves an `Unsigned` attribute value, as an unsigned 32-bit integer
`u_64_value()`	Retrieves a `Bigunsigned` attribute value, as an unsigned 64-bit integer
`u_char_value()`	Retrieves a `Char` attribute value, as an unsigned `char`
`u_medium_value()`	Retrieves a `Mediumunsigned` attribute value, as an unsigned 32-bit integer

Name	Description
`u_short_value()`	Retrieves a `Smallunsigned` attribute value, as an unsigned 16-bit integer

Note

The `NdbRecAttr` class has no public constructor; an instance of this object is created using `NdbTransaction::execute()`. For information about the destructor, which is public, see Section 2.3.26.1, "~NdbRecAttr()".

Types. The `NdbRecAttr` class defines no public types.

2.3.26.1 ~NdbRecAttr()

Description. The `NdbRecAttr` class destructor method.

Important

You should delete only copies of `NdbRecAttr` objects that were created in your application using the `clone()` method.

Signature.

```
~NdbRecAttr
    (
      void
    )
```

Parameters. *None*.

Return value. *None*.

2.3.26.2 NdbRecAttr::aRef()

Description. This method is used to obtain a reference to an attribute value, as a `char` pointer. This pointer is aligned appropriately for the data type. The memory is released by the NDB API when `NdbTransaction::close()` is executed on the transaction which read the value.

Signature.

```
char* aRef
    (
      void
    ) const
```

Parameters. A pointer to the attribute value. Because this pointer is constant, this method can be called anytime after `NdbOperation::getValue()` has been called.

Return value. *None*.

2.3.26.3 NdbRecAttr::char_value()

Description. This method gets a `Char` value stored in an `NdbRecAttr` object, and returns it as a `char`.

Signature.

```
char char_value
    (
      void
```

```
    ) const
```

Parameters. *None*.

Return value. A `char` value.

2.3.26.4 NdbRecAttr::clone()

Description. This method creates a deep copy of an `NdbRecAttr` object.

> **Note**
>
> The copy created by this method should be deleted by the application when no longer needed.

Signature.

```
NdbRecAttr* clone
    (
      void
    ) const
```

Parameters. *None*.

Return value. An `NdbRecAttr` object. This is a complete copy of the original, including all data.

2.3.26.5 NdbRecAttr::double_value()

Description. This method gets a `Double` value stored in an `NdbRecAttr` object, and returns it as a double.

Signature.

```
double double_value
    (
      void
    ) const
```

Parameters. *None*.

Return value. A double (8 bytes).

2.3.26.6 NdbRecAttr::float_value()

Description. This method gets a `Float` value stored in an `NdbRecAttr` object, and returns it as a float.

Signature.

```
float float_value
    (
      void
    ) const
```

Parameters. *None*.

Return value. A float (4 bytes).

2.3.26.7 NdbRecAttr::get_size_in_bytes()

Description. You can use this method to obtain the size of an attribute (element).

Signature.

```
Uint32 get_size_in_bytes
    (
      void
    ) const
```

Parameters. *None*.

Return value. The attribute size in bytes, as an unsigned 32-bit integer.

2.3.26.8 NdbRecAttr::getColumn()

Description. This method is used to obtain the column to which the attribute belongs.

Signature.

```
const NdbDictionary::Column* getColumn
    (
      void
    ) const
```

Parameters. *None*.

Return value. A pointer to a `Column` object.

2.3.26.9 NdbRecAttr::getType()

Description. This method is used to obtain the column's data type.

Signature.

```
NdbDictionary::Column::Type getType
    (
      void
    ) const
```

Parameters. *None*.

Return value. An `Column::Type` value.

2.3.26.10 NdbRecAttr::int8_value()

Description. This method gets a `Small` value stored in an `NdbRecAttr` object, and returns it as an 8-bit signed integer.

Signature.

```
Int8 int8_value
    (
      void
    ) const
```

Parameters. *None*.

Return value. An 8-bit signed integer.

2.3.26.11 NdbRecAttr::int32_value()

Description. This method gets an `Int` value stored in an `NdbRecAttr` object, and returns it as a 32-bit signed integer.

Signature.

```
Int32 int32_value
    (
      void
    ) const
```

Parameters. *None*.

Return value. A 32-bit signed integer.

2.3.26.12 NdbRecAttr::int64_value()

Description. This method gets a `Bigint` value stored in an `NdbRecAttr` object, and returns it as a 64-bit signed integer.

Signature.

```
Int64 int64_value
    (
      void
    ) const
```

Parameters. *None*.

Return value. A 64-bit signed integer.

2.3.26.13 NdbRecAttr::isNULL()

Description. This method checks whether an attribute value is `NULL`.

Signature.

```
int isNULL
    (
      void
    ) const
```

Parameters. *None*.

Return value. One of the following three values:

- `-1`: The attribute value is not defined due to an error.
- `0`: The attribute value is defined, but is not `NULL`.
- `1`: The attribute value is defined and is `NULL`.

Important

In the event that `NdbTransaction::execute()` has not yet been called, the value returned by `isNULL()` is not determined.

2.3.26.14 NdbRecAttr::medium_value()

Description. Gets the value of a `Mediumint` value stored in an `NdbRecAttr` object, and returns it as a 32-bit signed integer.

Signature.

```
Int32 medium_value
    (
      void
    ) const
```

Parameters. *None*.

Return value. A 32-bit signed integer.

2.3.26.15 NdbRecAttr::short_value()

Description. This method gets a `Smallint` value stored in an `NdbRecAttr` object, and returns it as a 16-bit signed integer (short).

Signature.

```
short short_value
    (
      void
    ) const
```

Parameters. *None*.

Return value. A 16-bit signed integer.

2.3.26.16 NdbRecAttr::u_8_value()

Description. This method gets a `Smallunsigned` value stored in an `NdbRecAttr` object, and returns it as an 8-bit unsigned integer.

Signature.

```
Uint8 u_8_value
    (
      void
    ) const
```

Parameters. *None*.

Return value. An 8-bit unsigned integer.

2.3.26.17 NdbRecAttr::u_32_value()

Description. This method gets an `Unsigned` value stored in an `NdbRecAttr` object, and returns it as a 32-bit unsigned integer.

Signature.

```
Uint32 u_32_value
    (
      void
    ) const
```

Parameters. *None*.

Return value. A 32-bit unsigned integer.

2.3.26.18 NdbRecAttr::u_64_value()

Description. This method gets a `Bigunsigned` value stored in an `NdbRecAttr` object, and returns it as a 64-bit unsigned integer.

Signature.

```
Uint64 u_64_value
    (
      void
```

```
    ) const
```

Parameters. *None*.

Return value. A 64-bit unsigned integer.

2.3.26.19 NdbRecAttr::u_char_value()

Description. This method gets a `Char` value stored in an `NdbRecAttr` object, and returns it as an unsigned `char`.

Signature.

```
Uint8 u_char_value
    (
      void
    ) const
```

Parameters. *None*.

Return value. An 8-bit unsigned `char` value.

2.3.26.20 NdbRecAttr::u_medium_value()

Description. This method gets an `Mediumunsigned` value stored in an `NdbRecAttr` object, and returns it as a 32-bit unsigned integer.

Signature.

```
Uint32 u_medium_value
    (
      void
    ) const
```

Parameters. *None*.

Return value. A 32-bit unsigned integer.

2.3.26.21 NdbRecAttr::u_short_value()

Description. This method gets a `Smallunsigned` value stored in an `NdbRecAttr` object, and returns it as a 16-bit (short) unsigned integer.

Signature.

```
Uint16 u_short_value
    (
      void
    ) const
```

Parameters. *None*.

Return value. A short (16-bit) unsigned integer.

2.3.27 The NdbRecord Interface

`NdbRecord` is an interface which provides a mapping to a full or a partial record stored in `NDB`. In the latter case, it can be used in conjunction with a bitmap to assist in access.

`NdbRecord` has no API methods of its own; rather it acts as a handle that can be passed between various method calls for use in many different sorts of operations, including the following operation types:

- Unique key reads and primary key reads
- Table scans and index scans
- DML operations involving unique keys or primary keys
- Operations involving index bounds

The same `NdbRecord` can be used simultaneously in multiple operations, transactions, and threads.

An `NdbRecord` can be created in NDB API programs by calling the `createRecord()` method of the `Dictionary` class. In addition, a number of NDB API methods have additional declarations that enable the programmer to leverage `NdbRecord`:

- `NdbScanOperation::nextResult()`
- `NdbScanOperation::lockCurrentTuple()`
- `NdbScanOperation::updateCurrentTuple()`
- `NdbScanOperation::deleteCurrentTuple()`
- `Dictionary::createRecord()`
- `Dictionary::releaseRecord()`
- `NdbTransaction::readTuple()`
- `NdbTransaction::insertTuple()`
- `NdbTransaction::updateTuple()`
- `NdbTransaction::writeTuple()`
- `NdbTransaction::deleteTuple()`
- `NdbTransaction::scanTable()`
- `NdbTransaction::scanIndex()`

The following members of `NdbIndexScanOperation` and `NdbDictionary` can also be used with `NdbRecord` scans:

- `IndexBound` is a structure used to describe index scan bounds.
- `RecordSpecification` is a structure used to specify columns and range offsets.

You can also use `NdbRecord` in conjunction with the new `PartitionSpec` structure to perform scans that take advantage of partition pruning, by means of a variant of `NdbIndexScanOperation::setBound()` that was added in the same NDB Cluster releases.

2.3.28 The NdbScanFilter Class

This section discusses the `NdbScanFilter` class and its public members.

Parent class. *None*

Child classes. *None*

Description. `NdbScanFilter` provides an alternative means of specifying filters for scan operations.

Important

Prior to MySQL 5.1.14, the comparison methods of this class did not work with `BIT` values (see Bug #24503).

Development of this interface continues; the characteristics of the `NdbScanFilter` class are likely to change further in future releases.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.58 NdbScanFilter class methods and descriptions

Name	Description
`NdbScanFilter()`	Constructor method
`~NdbScanFilter()`	Destructor method
`begin()`	Begins a compound (set of conditions)
`cmp()`	Compares a column value with an arbitrary value
`end()`	Ends a compound
`eq()`	Tests for equality
`ge()`	Tests for a greater-than-or-equal condition
`getNdbError()`	Provides access to error information
`getNdbOperation()`	Gets the associated `NdbOperation`
`gt()`	Tests for a greater-than condition
`isfalse()`	Defines a term in a compound as `FALSE`
`isnotnull()`	Tests whether a column value is not `NULL`
`isnull()`	Tests whether a column value is `NULL`
`istrue()`	Defines a term in a compound as `TRUE`
`le()`	Tests for a less-than-or-equal condition
`lt()`	Tests for a less-than condition
`ne()`	Tests for inequality

NdbScanFilter Integer Comparison Methods. `NdbScanFilter` provides several convenience methods which can be used in lieu of the `cmp()` method when the arbitrary value to be compared is an integer: `eq()`, `ge()`, `gt()`, `le()`, `lt()`, and `ne()`.

Each of these methods is essentially a wrapper for `cmp()` that includes an appropriate value of `BinaryCondition` for that method's *`condition`* parameter; for example, `NdbScanFilter::eq()` is defined like this:

```
int eq(int columnId, Uint32 value)
{
  return cmp(BinaryCondition::COND_EQ, columnId, &value, 4);
}
```

Types. The `NdbScanFilter` class defines two public types:

- `BinaryCondition`: The type of condition, such as lower bound or upper bound.
- `Group`: A logical grouping operator, such as `AND` or `OR`.

2.3.28.1 NdbScanFilter::begin()

Description. This method is used to start a compound, and specifies the logical operator used to group the conditions making up the compound. The default is AND.

Signature.

```
int begin
    (
      Group group = AND
    )
```

Parameters. A Group value: one of AND, OR, NAND, or NOR. See Section 2.3.28.14, "NdbScanFilter::Group", for additional information.

Return value. 0 on success, -1 on failure.

2.3.28.2 NdbScanFilter::BinaryCondition

Description. This type represents a condition based on the comparison of a column value with some arbitrary value—that is, a bound condition. A value of this type is used as the first argument to NdbScanFilter::cmp().

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.59 NdbScanFilter data type values and descriptions

Name	Description	Column type compared
COND_EQ	Equality (=)	any
COND_NE	Inequality (<> or !=)	any
COND_LE	Lower bound (<=)	any
COND_LT	Strict lower bound (<)	any
COND_GE	Upper bound (>=)	any
COND_GT	Strict upper bound (>)	any
COND_LIKE	LIKE condition	string or binary
COND_NOTLIKE	NOT LIKE condition	string or binary
COL_AND_MASK_EQ_MASK	Column value ANDed with bitmask is equal to bitmask	BIT
COL_AND_MASK_NE_MASK	Column value ANDed with bitmask is not equal to bitmask	BIT
COL_AND_MASK_EQ_ZERO	Column value ANDed with bitmask is equal to zero	BIT
COL_AND_MASK_NE_ZERO	Column value ANDed with bitmask is not equal to zero	BIT

When used in comparisons with COND_EQ, COND_NE, COND_LT, COND_LE, COND_GT, or COND_GE, fixed-length character and binary column values must be prefixed with the column size, and must be padded to length. This is not necessary for such values when used in COND_LIKE, COND_NOTLIKE, COL_AND_MASK_EQ_MASK, COL_AND_MASK_NE_MASK, COL_AND_MASK_EQ_ZERO, or COL_AND_MASK_NE_ZERO comparisons.

String comparisons. Strings compared using COND_LIKE and COND_NOTLIKE can use the pattern metacharacters % and _. See Section 2.3.28.3, "NdbScanFilter::cmp()", for more information.

BIT comparisons. The BIT comparison operators are COL_AND_MASK_EQ_MASK, COL_AND_MASK_NE_MASK, COL_AND_MASK_EQ_ZERO, and COL_AND_MASK_NE_ZERO.

Corresponding methods are available for `NdbInterpretedCode` and `NdbOperation`; for more information about these methods, see NdbInterpretedCode Bitwise Comparison Operations.

2.3.28.3 NdbScanFilter::cmp()

Description. This method is used to define a comparison between a given value and the value of a column. Beginning with NDB 8.0.18, it can also be used to compare two columns. (This method does not actually execute the comparison, which is done later when performing the scan for which this `NdbScanFilter` is defined.)

Note

In many cases, where the value to be compared is an integer, you can instead use one of several convenience methods provided by `NdbScanFilter` for this purpose. See NdbScanFilter Integer Comparison Methods.

Signature.

```
int cmp
    (
      BinaryCondition condition,
      int columnId,
      const void* value,
      Uint32 length = 0
    )
```

Addtionally, in NDB 8.0.18 and later:

```
int cmp
    (
      BinaryCondition condition,
      int ColumnId1,
      int ColumnId2
    )
```

Parameters. When used to compare a value with a column, this method takes the following parameters:

- *`condition`*: This represents the condition to be tested which compares the value of the column having the column ID *`columnID`* with some arbitrary value. The *`condition`* is a `BinaryCondition` value; for permitted values and the relations that they represent, see Section 2.3.28.2, "NdbScanFilter::BinaryCondition".

  The *`condition`* values `COND_LIKE` or `COND_NOTLIKE` are used to compare a column value with a string pattern.

- *`columnId`*: This is the column's identifier, which can be obtained using the `Column::getColumnNo()` method.

- *`value`*: The value to be compared, repesented as a pointer to `void`.

  When using a `COND_LIKE` or `COND_NOTLIKE` comparison condition, the *`value`* is treated as a string pattern. This string must not be padded or use a prefix. The string *`value`* can include the pattern metacharacters or "wildcard" characters `%` and `_`, which have the meanings shown here:

  Table 2.60 Pattern metacharacters used with COND_LIKE and COND_NOTLIKE comparisons

Metacharacter	Description
`%`	Matches zero or more characters
`_`	Matches exactly one character

  To match against a literal "%" or "_" character, use the backslash (`\`) as an escape character. To match a literal "\" character, use `\\`.

> **Note**
>
> These are the same wildcard characters that are supported by the SQL `LIKE` and `NOT LIKE` operators, and are interpreted in the same way. See String Comparison Functions and Operators, for more information.

- *`length`*: The length of the value to be compared. The default value is `0`. Using `0` for the *`length`* has the same effect as comparing to `NULL`, that is using the `isnull()` method.

When used to compare two columns, `cmp()` takes the following parameters:

- *`condition`*: The condition to be tested when comparing the columns. The condition may be any one of the `BinaryCondition` values `EQ`, `NE`, `LT`, `LE`, `GT`, or `GE`. Other values are not accepted.

- *`columnID1`*: ID of the first of the two columns to be compared.

- *`columnID1`*: ID of the second column.

Columns being compared using this method must be of exactly the same type. This includes length, precision, scale, and all other particulars.

Return value. This method returns an integer: `0` on success, and `-1` on failure.

2.3.28.4 NdbScanFilter Constructor

Description. This is the constructor method for `NdbScanFilter`, and creates a new instance of the class.

Signature.

```
NdbScanFilter
    (
      class NdbOperation* op
    )
```

Parameters. This method takes a single parameter, a pointer to the `NdbOperation` to which the filter applies.

Return value. A new instance of `NdbScanFilter`.

Destructor. The destructor takes no arguments and does not return a value. It should be called to remove the `NdbScanFilter` object when it is no longer needed.

2.3.28.5 NdbScanFilter::end()

Description. This method completes a compound, signalling that there are no more conditions to be added to it.

Signature.

```
int end
    (
      void
    )
```

Parameters. *None.*

Return value. Returns `0` on success, or `-1` on failure.

2.3.28.6 NdbScanFilter::eq()

Description. This method is used to perform an equality test on a column value and an integer.

Signature.

```
int eq
    (
      int    ColId,
      Uint32 value
    )
```

or

```
int eq
    (
      int    ColId,
      Uint64 value
    )
```

Parameters. This method takes two parameters, listed here:

- The ID (*ColId*) of the column whose value is to be tested
- An integer with which to compare the column value; this integer may be either 32-bit or 64-bit, and is unsigned in either case.

Return value. Returns `0` on success, or `-1` on failure.

2.3.28.7 NdbScanFilter::isfalse()

Description. Defines a term of the current group as `FALSE`.

Signature.

```
int isfalse
    (
      void
    )
```

Parameters. *None*.

Return value. `0` on success, or `-1` on failure.

2.3.28.8 NdbScanFilter::isnotnull()

Description. This method is used to check whether a column value is not `NULL`.

Signature.

```
int isnotnull
    (
      int ColId
    )
```

Parameters. The ID of the column whose value is to be tested.

Return value. Returns `0`, if the column value is not `NULL`.

2.3.28.9 NdbScanFilter::isnull()

Description. This method is used to check whether a column value is `NULL`.

Signature.

```
int isnull
    (
      int ColId
```

```
    )
```

Parameters. The ID of the column whose value is to be tested.

Return value. Returns `0`, if the column value is `NULL`.

2.3.28.10 NdbScanFilter::istrue()

Description. Defines a term of the current group as `TRUE`.

Signature.

```
int istrue
    (
      void
    )
```

Parameters. *None*.

Return value. Returns `0` on success, `-1` on failure.

2.3.28.11 NdbScanFilter::ge()

Description. This method is used to perform a greater-than-or-equal test on a column value and an integer.

Signature. This method accepts both 32-bit and 64-bit values, as shown here:

```
int ge
    (
      int    ColId,
      Uint32 value
    )


int ge
    (
      int    ColId,
      Uint64 value
    )
```

Parameters. Like `eq()`, `lt()`, `le()`, and the other `NdbScanFilter` methods of this type, this method takes two parameters:

- The ID (*`ColId`*) of the column whose value is to be tested
- An integer with which to compare the column value; this integer may be either 32-bit or 64-bit, and is unsigned in either case.

Return value. `0` on success; `-1` on failure.

2.3.28.12 NdbScanFilter::getNdbError()

Description. Because errors encountered when building an `NdbScanFilter` do not propagate to any involved `NdbOperation` object, it is necessary to use this method to access error information.

Signature.

```
const NdbError& getNdbError
    (
      void
    )
```

Parameters. *None*.

Return value. A reference to an `NdbError`.

2.3.28.13 NdbScanFilter::getNdbOperation()

Description. If the `NdbScanFilter` was constructed with an `NdbOperation`, this method can be used to obtain a pointer to that `NdbOperation` object.

Signature.

```
NdbOperation* getNdbOperation
    (
      void
    )
```

Parameters. *None*.

Return value. A pointer to the `NdbOperation` associated with this `NdbScanFilter`, if there is one. Otherwise, `NULL`.

2.3.28.14 NdbScanFilter::Group

Description. This type is used to describe logical (grouping) operators, and is used with the `begin()` method. (See Section 2.3.28.1, "NdbScanFilter::begin()".)

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.61 NdbScanFilter::Group data type values and descriptions

Value	Description
`AND`	Logical `AND`: `A AND B AND C`
`OR`	Logical `OR`: `A OR B OR C`
`NAND`	Logical `NOT AND`: `NOT (A AND B AND C)`
`NOR`	Logical `NOT OR`: `NOT (A OR B OR C)`

2.3.28.15 NdbScanFilter::gt()

Description. This method is used to perform a greater-than (strict upper bound) test on a column value and an integer.

Signature. This method accommodates both 32-bit and 64-bit values:

```
int gt
    (
      int    ColId,
      Uint32 value
    )


int gt
    (
      int    ColId,
      Uint64 value
    )
```

Parameters. Like the other `NdbScanFilter` methods of this type, this method takes two parameters:

- The ID (*`ColId`*) of the column whose value is to be tested
- An integer with which to compare the column value; this integer may be either 32-bit or 64-bit, and is unsigned in either case.

Return value. `0` on success; `-1` on failure.

2.3.28.16 NdbScanFilter::le()

Description. This method is used to perform a less-than-or-equal test on a column value and an integer.

Signature. This method has two variants, to accommodate 32-bit and 64-bit values:

```
int le
    (
      int    ColId,
      Uint32 value
    )


int le
    (
      int    ColId,
      Uint64 value
    )
```

Parameters. Like the other `NdbScanFilter` methods of this type, this method takes two parameters:

- The ID (*`ColId`*) of the column whose value is to be tested
- An integer with which to compare the column value; this integer may be either 32-bit or 64-bit, and is unsigned in either case.

Return value. Returns `0` on success, or `-1` on failure.

2.3.28.17 NdbScanFilter::lt()

Description. This method is used to perform a less-than (strict lower bound) test on a column value and an integer.

Signature. This method has 32-bit and 64-bit variants, as shown here:

```
int lt
    (
      int    ColId,
      Uint32 value
    )

int lt
    (
      int    ColId,
      Uint64 value
    )
```

Parameters. Like `eq()`, `ne()`, and the other `NdbScanFilter` methods of this type, this method takes two parameters, listed here:

- The ID (*`ColId`*) of the column whose value is to be tested
- An integer with which to compare the column value; this integer may be either 32-bit or 64-bit, and is unsigned in either case.

Return value. Retrturns `0` on success, or `-1` on failure.

2.3.28.18 NdbScanFilter::ne()

Description. This method is used to perform an inequality test on a column value and an integer.

Signature. This method has 32-bit and 64-bit variants, as shown here:

```
int ne
    (
      int    ColId,
      Uint32 value
    )

int ne
    (
      int    ColId,
      Uint64 value
    )
```

Parameters. Like `eq()` and the other `NdbScanFilter` methods of this type, this method takes two parameters:

- The ID (*`ColId`*) of the column whose value is to be tested
- An integer with which to compare the column value; this integer may be either 32-bit or 64-bit, and is unsigned in either case.

Return value. Returns `0` on success, or `-1` on failure.

2.3.29 The NdbScanOperation Class

This section describes the `NdbScanOperation` class and its class members.

Parent class. `NdbOperation`

Child classes. `NdbIndexScanOperation`

Description. The `NdbScanOperation` class represents a scanning operation used in a transaction. This class inherits from `NdbOperation`.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.62 NdbScanOperation class methods and descriptions

Name	Description
`close()`	Closes the scan
`deleteCurrentTuple()`	Deletes the current tuple
`lockCurrentTuple()`	Locks the current tuple
`nextResult()`	Gets the next tuple
`getNdbTransaction()`	Gets the `NdbTransaction` object for this scan
`getPruned()`	Used to find out whether this scan is pruned to a single partition
`readTuples()`	Reads tuples
`restart()`	Restarts the scan
`updateCurrentTuple()`	Updates the current tuple

Note

This class has no public constructor. To create an instance of `NdbScanOperation`, it is necessary to use the `NdbTransaction::getNdbScanOperation()` method.

Types. This class defines a single public type `ScanFlag`.

For more information about the use of `NdbScanOperation`, see Scan Operations, and Using Scans to Update or Delete Rows.

2.3.29.1 NdbScanOperation::close()

Description. Calling this method closes a scan. Rows returned by this scan are no longer available after the scan has been closed using this method.

> **Note**
>
> See Scans with exclusive locks, for information about multiple threads attempting to perform the same scan with an exclusive lock and how this can affect closing the scans.

Signature.

```
void close
    (
      bool forceSend = false,
      bool releaseOp = false
    )
```

Parameters. This method takes the two parameters listed here:

- *`forceSend`* defaults to `false`; call `close()` with this parameter set to `true` in order to force transactions to be sent.
- *`releaseOp`* also defaults to `false`; set this to `true` in order to release the operation.

  Prior to NDB 7.3.8, the buffer allocated by an `NdbScanOperation` for receiving the scanned rows was not released until the `NdbTransaction` owning the scan operation was closed (Bug #75128, Bug #20166585). In these and subsequent versions of NDB Cluster, the buffer is released whenever the cursor navigating the result set is closed using the `close()` method, regardless of the value of the *`releaseOp`* argument.

Return value. *None*.

2.3.29.2 NdbScanOperation::deleteCurrentTuple()

Description. This method is used to delete the current tuple.

Signature.

```
const NdbOperation* deleteCurrentTuple
    (
      NdbTransaction* takeOverTrans,
      const NdbRecord* record,
      char* row = 0,
      const unsigned char* mask = 0,
      const NdbOperation::OperationOptions* opts = 0,
      Uint32 sizeOfOpts = 0
    )
```

For more information, see Section 2.3.27, "The NdbRecord Interface".

Parameters. When used with the `NdbRecord` interface, this method takes the parameters listed here:

- The transaction (*`takeOverTrans`*) that should perform the lock; when using `NdbRecord` with scans, this parameter is not optional.
- The `NdbRecord` referenced by the scan. This *`record`* value is required, even if no records are being read.

- The *row* from which to read. Set this to NULL if no read is to occur.
- The *mask* pointer is optional. If it is present, then only columns for which the corresponding bit in the mask is set are retrieved by the scan.
- OperationOptions (*opts*) can be used to provide more finely-grained control of operation definitions. An OperationOptions structure is passed with flags indicating which operation definition options are present. Not all operation types support all operation options; the options supported for each type of operation are shown in the following table:

Table 2.63 Operation types for the NdbRecord OperationOptions

Operation type (Method)	OperationOptions Flags Supported
readTuple()	OO_ABORTOPTION, OO_GETVALUE, OO_PARTITION_ID, OO_INTERPRETED
insertTuple()	OO_ABORTOPTION, OO_SETVALUE, OO_PARTITION_ID, OO_ANYVALUE
updateTuple()	OO_ABORTOPTION, OO_SETVALUE, OO_PARTITION_ID, OO_INTERPRETED, OO_ANYVALUE
writeTuple()	OO_ABORTOPTION, OO_SETVALUE, OO_PARTITION_ID, OO_ANYVALUE
deleteTuple()	OO_ABORTOPTION, OO_GETVALUE, OO_PARTITION_ID, OO_INTERPRETED, OO_ANYVALUE

- The optional *sizeOfOptions* parameter is used to preserve backward compatibility of this interface with previous definitions of the OperationOptions structure. If an unusual size is detected by the interface implementation, it can use this to determine how to interpret the passed OperationOptions structure. To enable this functionality, the caller should pass sizeof(NdbOperation::OperationOptions) for the value of this argument.
- If options are specified, their length (*sizeOfOpts*) must be specified as well.

Return value. Returns 0 on success, or -1 on failure.

2.3.29.3 NdbScanOperation::getNdbTransaction()

Description. Gets the NdbTransaction object for this scan.

Signature.

```
NdbTransaction* getNdbTransaction
    (
      void
    ) const
```

Parameters. *None*.

Return value. A pointer to an NdbTransaction object.

2.3.29.4 NdbScanOperation::getPruned()

Description. This method is used to determine whether or not a given scan operation has been pruned to a single partition. For scans defined using NdbRecord, this method can be called before or after the scan is executed. For scans not defined using NdbRecord, getPruned() is valid only after the scan has been executed.

Signature.

```
bool getPruned
```

```
    (
      void
    ) const
```

Parameters. *None*.

Return value. Returns `true`, if the scan is pruned to a single table partition.

2.3.29.5 NdbScanOperation::lockCurrentTuple()

Description. This method locks the current tuple.

Signature. In MySQL 5.1 and later, this method can be called with an optional single parameter, in either of the two ways shown here:

```
NdbOperation* lockCurrentTuple
    (
      void
    )

NdbOperation* lockCurrentTuple
    (
      NdbTransaction* lockTrans
    )
```

The following signature is also supported for this method, when using `NdbRecord`:

```
NdbOperation *lockCurrentTuple
    (
      NdbTransaction* takeOverTrans,
      const NdbRecord* record,
      char* row = 0,
      const unsigned char* mask = 0
    )
```

This method also supports specifying one or more `OperationOptions` (also when using `NdbRecord`):

```
NdbOperation *lockCurrentTuple
    (
      NdbTransaction* takeOverTrans,
      const NdbRecord* record,
      char* row = 0,
      const unsigned char* mask = 0,
      const NdbOperation::OperationOptions* opts = 0,
      Uint32 sizeOfOptions = 0
    )
```

Parameters (old style). This method takes a single, optional parameter—the transaction that should perform the lock. If this is omitted, the transaction is the current one.

Parameters (when using NdbRecord). When using the `NdbRecord` interface, this method takes these parameters, as described in the following list:

- The transaction (*`takeOverTrans`*) that should perform the lock; when using `NdbRecord` with scans, this parameter is not optional.
- The `NdbRecord` referenced by the scan. This is required, even if no records are being read.
- The *`row`* from which to read. Set this to `NULL` if no read is to occur.
- The *`mask`* pointer is optional. If it is present, then only columns for which the corresponding bit in the mask is set are retrieved by the scan.
- The *`opts`* argument can take on any of the following `OperationOptions` values: `OO_ABORTOPTION`, `OO_GETVALUE`, and `OO_ANYVALUE`.

- If options are specified, their length (*sizeOfOptions*) must be specified as well.

> **Important**
>
> Calling an NdbRecord scan lock takeover on an NdbRecAttr-style scan is not valid, nor is calling an NdbRecAttr-style scan lock takeover on an NdbRecord-style scan.

Return value. This method returns a pointer to an NdbOperation object, or NULL.

2.3.29.6 NdbScanOperation::nextResult()

Description. This method is used to fetch the next tuple in a scan transaction. Following each call to nextResult(), the buffers and NdbRecAttr objects defined in NdbOperation::getValue() are updated with values from the scanned tuple.

When nextResult() is executed following end-of-file, NDB returns error code 4210 (Ndb sent more info than length specified) and the extra transaction object is freed by returning it to the idle list for the right TC node.

Signature. This method can be invoked in one of two ways. The first of these, shown here, is available beginning in MySQL 5.1:

```
int nextResult
    (
      bool fetchAllowed = true,
      bool forceSend = false
    )
```

It is also possible to use this method as shown here:

```
int nextResult
    (
      const char*& outRow,
      bool fetchAllowed = true,
      bool forceSend = false
    )
```

Parameters (2-parameter version). This method takes the following two parameters:

- Normally, the NDB API contacts the NDB kernel for more tuples whenever it is necessary; setting *fetchAllowed* to false keeps this from happening.

  Disabling *fetchAllowed* by setting it to false forces NDB to process any records it already has in its caches. When there are no more cached records it returns 2. You must then call nextResult() with *fetchAllowed* equal to true in order to contact NDB for more records.

  While nextResult(false) returns 0, you should transfer the record to another transaction using execute(NdbTransaction::NoCommit). When nextResult(false) returns 2, you should normally execute and commit the other transaction. This causes any locks to be transferred to the other transaction, updates or deletes to be made, and then, the locks to be released. Following this, you can call nextResult(true) to have more records fetched and cached in the NDB API.

  > **Note**
  >
  > If you do not transfer the records to another transaction, the locks on those records will be released the next time that the NDB Kernel is contacted for more records.

  Disabling *fetchAllowed* can be useful when you want to update or delete all of the records obtained in a given transaction, as doing so saves time and speeds up updates or deletes of scanned records.

- *`forceSend`* defaults to `false`, and can normally be omitted. However, setting this parameter to `true` means that transactions are sent immediately. See Section 1.3.4, "The Adaptive Send Algorithm", for more information.

Parameters (3-parameter version). This method can also be called with the following three parameters:

- Calling `nextResult()` sets a pointer to the next row in *`outRow`* (if returning 0). This pointer is valid (only) until the next call to `nextResult()` when *`fetchAllowed`* is true. The `NdbRecord` object defining the row format must be specified beforehand using `NdbTransaction::scanTable()` (or `NdbTransaction::scanIndex()`.

- When false, *`fetchAllowed`* forces `NDB` to process any records it already has in its caches. See the description for this parameter in the previous *Parameters* subsection for more details.

- Setting *`forceSend`* to `true` means that transactions are sent immediately, as described in the previous *Parameters* subsection, as well as in Section 1.3.4, "The Adaptive Send Algorithm".

Return value. This method returns one of the following 4 integer values, interpreted as shown in the following list:

- `-1`: Indicates that an error has occurred.

- `0`: Another tuple has been received.

- `1`: There are no more tuples to scan.

- `2`: There are no more cached records (invoke `nextResult(true)` to fetch more records).

Example. See Section 2.5.4, "NDB API Basic Scanning Example".

2.3.29.7 NdbScanOperation::readTuples()

Description. This method is used to perform a scan.

Signature.

```
virtual int readTuples
    (
      LockMode mode = LM_Read,
      Uint32   flags = 0,
      Uint32   parallel = 0,
      Uint32   batch = 0
    )
```

Parameters. This method takes the four parameters listed here:

- The lock *`mode`*; this is a `LockMode` value.

  Scans with exclusive locks. When scanning with an exclusive lock, extra care must be taken due to the fact that, if two threads perform this scan simultaneously over the same range, then there is a significant probability of causing a deadlock. The likelihood of a deadlock is increased if the scan is also ordered (that is, using `SF_OrderBy` or `SF_Descending`).

  The `NdbScanOperation::close()` method is also affected by this deadlock, since all outstanding requests are serviced before the scan is actually closed.

- One or more `ScanFlag` values. Multiple values are `OR`'ed together

- The number of fragments to scan in *`parallel`*; use `0` to require that the maximum possible number be used.

- The *`batch`* parameter specifies how many records will be returned to the client from the server by the next `NdbScanOperation::nextResult(true)` method call. Use `0` to specify the maximum automatically.

Note

This parameter was ignored prior to MySQL 5.1.12, and the maximum was used (see Bug #20252).

Return value. Returns `0` on success, `-1` on failure.

2.3.29.8 NdbScanOperation::restart()

Description. Use this method to restart a scan without changing any of its `getValue()` calls or search conditions.

Signature.

```
int restart
    (
      bool forceSend = false
    )
```

Parameters. Call this method with *`forceSend`* set to `true` in order to force the transaction to be sent.

Return value. `0` on success; `-1` on failure.

2.3.29.9 NdbScanOperation::ScanFlag

Description. Values of this type are the scan flags used with the `readTuples()` method. More than one may be used, in which case, they are `OR`'ed together as the second argument to that method. See Section 2.3.29.7, “NdbScanOperation::readTuples()”, for more information.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.64 NdbScanOperation::ScanFlag values and descriptions

Value	Description
`SF_TupScan`	Scan in TUP order (that is, in the order of the rows in memory). Applies to table scans only.
`SF_DiskScan`	Scan in disk order (order of rows on disk). Applies to table scans only.
`SF_OrderBy`	Ordered index scan (ascending); rows returned from an index scan are sorted, and ordered on the index key. Scans in either ascending or descending order are affected by this flag, which causes the API to perform a merge-sort among the ordered scans of each fragment to obtain a single sorted result set. *Notes*: • Ordered indexes are distributed, with one ordered index for each fragment of a table. • Range scans are often parallel across all index fragments. Occasionally, they can be pruned to one index fragment. • Each index fragment range scan can return results in either ascending or descending order. Ascending is the default; to choose descending order, set the `SF_Descending` flag. • When multiple index fragments are scanned in parallel, the results are sent back to NDB where they can optionally

Value	Description
	be merge-sorted before being returned to the user. This merge sorting is controlled using the `SF_OrderBy` and `SF_OrderByFull` flags. • If `SF_OrderBy` or `SF_OrderByFull` is not used, the results from each index fragment are in order (either ascending or descending), but results from different fragments may be interleaved. • When using `SF_OrderBy` or `SF_OrderByFull`, some extra constraints are imposed internally; these are listed here: 1. If the range scan is not pruned to one index fragment then all index fragments must be scanned in parallel. (Unordered scans can be executed with less than full parallelism.) 2. Results from every index fragment must be available before returning any rows, to ensure a correct merge sort. This serialises the “scrolling” of the scan, potentially resulting in lower row throughput. 3. Unordered scans can return rows to the API client before all index fragments have returned any batches, and can overlap next-batch requests with row processing.
`SF_OrderByFull`	This is the same as `SF_OrderBy`, except that all key columns are added automatically to the read bitmask.
`SF_Descending`	Causes an ordered index scan to be performed in descending order.
`SF_ReadRangeNo`	For index scans, when this flag is set, `NdbIndexScanOperation::get_range_no()` can be called to read back the `range_no` defined in `NdbIndexScanOperation::setBound()`. In addition, when this flag is set, and `SF_OrderBy` or `SF_OrderByFull` is also set, results from ranges are returned in their entirety before any results are returned from subsequent ranges.
`SF_MultiRange`	Indicates that this scan is part of a multirange scan; each range is scanned separately.
`SF_KeyInfo`	Requests `KeyInfo` to be sent back to the caller. This enables the option to take over the row lock taken by the scan, using `lockCurrentTuple()`, by making sure that the kernel sends back the information needed to identify the row and the lock. This flag is enabled by default for scans using `LM_Exclusive`, but must be explicitly specified to enable the taking over of `LM_Read` locks. (See the `LockMode` documentation for more information.)

2.3.29.10 NdbScanOperation::updateCurrentTuple()

Description. This method is used to update the current tuple.

Signature. Originally, this method could be called with a single. optional parameter, in either of the ways shown here:

```
NdbOperation* updateCurrentTuple
    (
      void
    )
```

```
NdbOperation* updateCurrentTuple
    (
      NdbTransaction* updateTrans
    )
```

It is also possible to employ this method, when using `NdbRecord` with scans, as shown here:

```
NdbOperation* updateCurrentTuple
    (
      NdbTransaction*       takeOverTrans,
      const NdbRecord*      record,
      const char*           row,
      const unsigned char* mask = 0
    )
```

See Section 2.3.27, “The NdbRecord Interface”, for more information.

Parameters (original). This method takes a single, optional parameter—the transaction that should perform the lock. If this is omitted, the transaction is the current one.

Parameters (when using NdbRecord). When using the `NdbRecord` interface, this method takes the following parameters, as described in the following list:

- The takeover transaction (*`takeOverTrans`*).
- The *`record`* (`NdbRecord` object) referencing the column used for the scan.
- The *`row`* to read from. If no attributes are to be read, set this equal to `NULL`.
- The *`mask`* pointer is optional. If it is present, then only columns for which the corresponding bit in the mask is set are retrieved by the scan.

Return value. This method returns an `NdbOperation` object or `NULL`.

2.3.30 The NdbTransaction Class

This section describes the `NdbTransaction` class and its public members.

Parent class. *None*

Child classes. *None*

Description. A transaction is represented in the NDB API by an `NdbTransaction` object, which belongs to an `Ndb` object and is created using `Ndb::startTransaction()`. A transaction consists of a list of operations represented by the `NdbOperation` class, or by one of its subclasses —`NdbScanOperation`, `NdbIndexOperation`, or `NdbIndexScanOperation`. Each operation access exactly one table.

Using Transactions. After obtaining an `NdbTransaction` object, it is employed as follows:

1. An operation is allocated to the transaction using any one of the following methods:

   - `getNdbOperation()`
   - `getNdbScanOperation()`
   - `getNdbIndexOperation()`
   - `getNdbIndexScanOperation()`

   Calling one of these methods defines the operation. Several operations can be defined on the same `NdbTransaction` object, in which case they are executed in parallel. When all operations are defined, the `execute()` method sends them to the `NDB` kernel for execution.

2. The `execute()` method returns when the `NDB` kernel has completed execution of all operations previously defined.

> **Important**
>
> All allocated operations should be properly defined *before* calling the `execute()` method.

3. `execute()` operates in one of the three modes listed here:

   - `NdbTransaction::NoCommit`: Executes operations without committing them.
   - `NdbTransaction::Commit`: Executes any remaining operation and then commits the complete transaction.
   - `NdbTransaction::Rollback`: Rolls back the entire transaction.

   `execute()` is also equipped with an extra error handling parameter, which provides the two alternatives listed here:

   - `NdbOperation::AbortOnError`: Any error causes the transaction to be aborted. This is the default behavior.
   - `NdbOperation::AO_IgnoreError`: The transaction continues to be executed even if one or more of the operations defined for that transaction fails.

> **Note**
>
> In MySQL 5.1.15 and earlier, these values were `NdbTransaction::AbortOnError` and `NdbTransaction::AO_IgnoreError`.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.65 NdbTransaction class methods and descriptions

Name	Description
`close()`	Closes a transaction
`commitStatus()`	Gets the transaction's commit status
`deleteTuple()`	Delete a tuple using `NdbRecord`
`execute()`	Executes a transaction
`executePendingBlobOps()`	Executes a transaction in `NoCommit` mode if it includes any blob part operations of the specified types that are not yet executed.
`getGCI()`	Gets a transaction's global checkpoint ID (GCI)
`getMaxPendingBlobReadBytes()`	Get the current `BLOB` read batch size
`getMaxPendingBlobWriteBytes()`	Get the current `BLOB` write batch size
`getNdbError()`	Gets the most recent error
`getNdbErrorLine()`	Gets the line number where the most recent error occurred
`getNdbErrorOperation()`	Gets the most recent operation which caused an error
`getNextCompletedOperation()`	Gets operations that have been executed; used for finding errors
`getNdbOperation()`	Gets an `NdbOperation`
`getNdbScanOperation()`	Gets an `NdbScanOperation`
`getNdbIndexOperation()`	Gets an `NdbIndexOperation`

Name	Description
getNdbIndexScanOperation()	Gets an NdbIndexScanOperation
getTransactionId()	Gets the transaction ID
insertTuple()	Insert a tuple using NdbRecord
readTuple()	Read a tuple using NdbRecord
refresh()	Keeps a transaction from timing out
releaseLockHandle()	Release an NdbLockHandle object once it is no longer needed
scanIndex()	Perform an index scan using NdbRecord
scanTable()	Perform a table scan using NdbRecord
setMaxPendingBlobReadBytes()	Set the BLOB read batch size
setMaxPendingBlobWriteBytes()	Set the BLOB write batch size
setSchemaObjectOwnerChecks()	Enable or disable schema object ownership checks
unlock()	Create an unlock operation on the current transaction
updateTuple()	Update a tuple using NdbRecord
writeTuple()	Write a tuple using NdbRecord

The methods readTuple(), insertTuple(), updateTuple(), writeTuple(), deleteTuple(), scanTable(), and scanIndex() require the use of NdbRecord.

Types. NdbTransaction defines 2 public types as shown in the following table:

Table 2.66 NdbTransaction class methods and descriptions

Name	Description
CommitStatusType()	Describes the transaction's commit status
ExecType()	Determines whether the transaction should be committed or rolled back

2.3.30.1 NdbTransaction::close()

Description. This method closes a transaction. It is equivalent to calling Ndb::closeTransaction().

⚠

Important

If the transaction has not yet been committed, it is aborted when this method is called. See Section 2.3.16.35, “Ndb::startTransaction()”.

Signature.

```
void close
    (
      void
    )
```

Parameters. *None*.

Return value. *None*.

2.3.30.2 NdbTransaction::commitStatus()

Description. This method gets the transaction's commit status.

Signature.

```
CommitStatusType commitStatus
    (
      void
    )
```

Parameters. *None*.

Return value. The commit status of the transaction, a `CommitStatusType` value. See Section 2.3.30.3, "NdbTransaction::CommitStatusType".

2.3.30.3 NdbTransaction::CommitStatusType

Description. This type is used to describe a transaction's commit status.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.67 NdbTransaction::CommitStatusType values and descriptions

Name	Description
`NotStarted`	The transaction has not yet been started.
`Started`	The transaction has started, but is not yet committed.
`Committed`	The transaction has completed, and has been committed.
`Aborted`	The transaction was aborted.
`NeedAbort`	The transaction has encountered an error, but has not yet been aborted.

A transaction's commit status ca be read using the `commitStatus()` method. See Section 2.3.30.2, "NdbTransaction::commitStatus()".

2.3.30.4 NdbTransaction::deleteTuple()

Description. Deletes a tuple using `NdbRecord`.

Signature.

```
const NdbOperation* deleteTuple
    (
      const NdbRecord* key_rec,
      const char* key_row,
      const NdbRecord* result_rec,
      char* result_row,
      const unsigned char* result_mask = 0,
      const NdbOperation::OperationOptions* opts = 0,
      Uint32 sizeOfOptions = 0
    )
```

Parameters. This method takes the following parameters:

- *`key_rec`* is a pointer to an `NdbRecord` for either a table or an index. If on a table, then the delete operation uses a primary key; if on an index, then the operation uses a unique key. In either case, the *`key_rec`* must include all columns of the key.

- The *`key_row`* passed to this method defines the primary or unique key of the tuple to be deleted, and must remain valid until `execute()` is called.

- The *`result_rec`* is the `NdbRecord` to be used.

- The *`result_row`* can be `NULL` if no attributes are to be returned.

- The *`result_mask`*, if not `NULL`, defines a subset of attributes to be read and returned to the client. The mask is copied, and so does not need to remain valid after the call to this method returns.

- `OperationOptions` (*`opts`*) can be used to provide more finely-grained control of operation definitions. An `OperationOptions` structure is passed with flags indicating which operation definition options are present. Not all operation types support all operation options; for the options supported by each type of operation, see Section 2.3.30.21, "NdbTransaction::readTuple()".

- The optional *`sizeOfOptions`* parameter provides backward compatibility of this interface with previous definitions of the `OperationOptions` structure. If an unusual size is detected by the interface implementation, it can use this to determine how to interpret the passed `OperationOptions` structure. To enable this functionality, the caller should pass `sizeof(NdbOperation::OperationOptions)` for the value of this argument.

Return value. A `const` pointer to the `NdbOperation` representing this write operation. The operation can be checked for errors if necessary.

2.3.30.5 NdbTransaction::ExecType

Description. This type sets the transaction's execution type; that is, whether it should execute, execute and commit, or abort. It is used as a parameter to the `execute()` method. (See Section 2.3.30.6, "NdbTransaction::execute()".)

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 2.68 NdbTransaction::ExecType values and descriptions

Name	Description
`NoCommit`	The transaction should execute, but not commit.
`Commit`	The transaction should execute and be committed.
`Rollback`	The transaction should be rolled back.

2.3.30.6 NdbTransaction::execute()

Description. This method is used to execute a transaction.

Signature.

```
int execute
    (
      ExecType execType,
      NdbOperation::AbortOption abortOption = NdbOperation::DefaultAbortOption,
      int force = 0
    )
```

Parameters. The execute method takes the three parameters listed here:

- The execution type (`ExecType` value); see Section 2.3.30.5, "NdbTransaction::ExecType", for more information and possible values.

- An abort option (`NdbOperation::AbortOption` value).

  Errors arising from this method are found with `NdbOperation::getNdbError()` rather than `NdbTransaction::getNdbError()`. information.

- A *`force`* parameter, which determines when operations should be sent to the `NDB` Kernel. It takes ones of the values listed here:

  - `0`: Nonforced; detected by the adaptive send algorithm.

- 1: Forced; detected by the adaptive send algorithm.
- 2: Nonforced; not detected by the adaptive send algorithm.

See Section 1.3.4, “The Adaptive Send Algorithm”, for more information.

Return value. Returns 0 on success, or -1 on failure. The fact that the transaction did not abort does not necessarily mean that each operation was successful; you must check each operation individually for errors.

In MySQL 5.1.15 and earlier versions, this method returned -1 for some errors even when the trasnsaction itself was not aborted; beginning with MySQL 5.1.16, this method reports a failure *if and only if* the transaction was aborted. (This change was made due to the fact it had been possible to construct cases where there was no way to determine whether or not a transaction was actually aborted.) However, the transaction's error information is still set in such cases to reflect the actual error code and category.

This means, in the case where a **NoDataFound** error is a possibility, you must now check for it explicitly, as shown in this example:

```
Ndb_cluster_connection myConnection;

if( myConnection.connect(4, 5, 1) )
{
  cout << "Unable to connect to cluster within 30 secs." << endl;
  exit(-1);
}

Ndb myNdb(&myConnection, "test");

//  define operations...

myTransaction = myNdb->startTransaction();

if(myTransaction->getNdbError().classification == NdbError:NoDataFound)
{
  cout << "No records found." << endl;
  //  ...
}

myNdb->closeTransaction(myTransaction);
```

2.3.30.7 NdbTransaction::executePendingBlobOps()

Description. This method executes the transaction with ExecType equal to NoCommit if there remain any blob part operations of the given types which have not yet been executed.

Signature.

```
int executePendingBlobOps
  (
    Uint8 flags = 0xFF
  )
```

Parameters. The *flags* argument is the result of a bitwise OR, equal to 1 << *optype*, where *optype* is an NdbOperation::Type. The default corresponds to PrimaryKeyAccess.

Return value. Returns 0 on success, or -1 on failure. The fact that the transaction did not abort does not necessarily mean that each operation was successful; you must check each operation individually for errors.

2.3.30.8 NdbTransaction::getGCI()

Description. This method retrieves the transaction's global checkpoint ID (GCI).

Each committed transaction belongs to a GCI. The log for the committed transaction is saved on disk when a global checkpoint occurs.

By comparing the GCI of a transaction with the value of the latest GCI restored in a restarted NDB Cluster, you can determine whether or not the transaction was restored.

Note

Whether or not the global checkpoint with this GCI has been saved on disk cannot be determined by this method.

Important

The GCI for a scan transaction is undefined, since no updates are performed in scan transactions.

Signature.

```
int getGCI
    (
      void
    )
```

Parameters. *None*.

Return value. The transaction's GCI, or `-1` if none is available.

Note

No GCI is available until `execute()` has been called with `ExecType::Commit`.

2.3.30.9 NdbTransaction::getMaxPendingBlobReadBytes()

Description. Gets the current batch size in bytes for `BLOB` read operations. When the volume of `BLOB` data to be read within a given transaction exceeds this amount, all of the transaction's pending `BLOB` read operations are executed.

Signature.

```
Uint32 getMaxPendingBlobReadBytes
    (
      void
    ) const
```

Parameters. *None*.

Return value. The current `BLOB` read batch size, in bytes. See Section 2.3.30.26, “NdbTransaction::setMaxPendingBlobReadBytes()”, for more information.

2.3.30.10 NdbTransaction::getMaxPendingBlobWriteBytes()

Description. Gets the current batch size in bytes for `BLOB` write operations. When the volume of `BLOB` data to be written within a given transaction exceeds this amount, all of the transaction's pending `BLOB` write operations are executed.

Signature.

```
Uint32 getMaxPendingBlobWriteBytes
    (
      void
    ) const
```

Parameters. *None*.

Return value. The current `BLOB` write batch size, in bytes. See Section 2.3.30.27, “NdbTransaction::setMaxPendingBlobWriteBytes()”, for more information.

2.3.30.11 NdbTransaction::getNdbError()

Description. This method is used to obtain the most recent error (`NdbError`).

Signature.

```
const NdbError& getNdbError
    (
      void
    ) const
```

Parameters. *None*.

Return value. A reference to an `NdbError` object.

> **Note**
>
> For additional information about handling errors in transactions, see Error Handling.

2.3.30.12 NdbTransaction::getNdbErrorLine()

Description. This method return the line number where the most recent error occurred.

Signature.

```
int getNdbErrorLine
    (
      void
    )
```

Parameters. *None*.

Return value. The line number of the most recent error.

> **Note**
>
> For additional information about handling errors in transactions, see Error Handling.

2.3.30.13 NdbTransaction::getNdbErrorOperation()

Description. This method retrieves the operation that caused an error.

> **Tip**
>
> To obtain more information about the actual error, use the `NdbOperation::getNdbError()` method of the `NdbOperation` object returned by `getNdbErrorOperation()`.

Signature.

```
NdbOperation* getNdbErrorOperation
    (
      void
    )
```

Parameters. *None*.

Return value. A pointer to an `NdbOperation`.

> **Note**
>
> For additional information about handling errors in transactions, see Error Handling.

2.3.30.14 NdbTransaction::getNdbIndexOperation()

Description. This method is used to create an `NdbIndexOperation` associated with a given table.

> **Note**
>
> All index operations within the same transaction must be initialised with this method. Operations must be defined before they are executed.

Signature.

```
NdbIndexOperation* getNdbIndexOperation
    (
      const NdbDictionary::Index* index
    )
```

Parameters. The `Index` object on which the operation is to be performed.

Return value. A pointer to the new `NdbIndexOperation`.

2.3.30.15 NdbTransaction::getNdbIndexScanOperation()

Description. This method is used to create an `NdbIndexScanOperation` associated with a given table.

> **Note**
>
> All index scan operations within the same transaction must be initialised with this method. Operations must be defined before they are executed.

Signature.

```
NdbIndexScanOperation* getNdbIndexScanOperation
    (
      const NdbDictionary::Index* index
    )
```

Parameters. The `Index` object on which the operation is to be performed.

Return value. A pointer to the new `NdbIndexScanOperation`.

2.3.30.16 NdbTransaction::getNdbOperation()

Description. This method is used to create an `NdbOperation` associated with a given table.

> **Note**
>
> All operations within the same transaction must be initialised with this method. Operations must be defined before they are executed.

Signature.

```
NdbOperation* getNdbOperation
    (
      const NdbDictionary::Table* table
```

```
    )
```

Parameters. The `Table` object on which the operation is to be performed.

Return value. A pointer to the new `NdbOperation`.

2.3.30.17 NdbTransaction::getNdbScanOperation()

Description. This method is used to create an `NdbScanOperation` associated with a given table.

Note

All scan operations within the same transaction must be initialised with this method. Operations must be defined before they are executed.

Signature.

```
NdbScanOperation* getNdbScanOperation
    (
      const NdbDictionary::Table* table
    )
```

Parameters. The `Table` object on which the operation is to be performed.

Return value. A pointer to the new `NdbScanOperation`.

2.3.30.18 NdbTransaction::getNextCompletedOperation()

Description. This method is used to retrieve a transaction's completed operations. It is typically used to fetch all operations belonging to a given transaction to check for errors.

`NdbTransaction::getNextCompletedOperation(NULL)` returns the transaction's first `NdbOperation` object; `NdbTransaction::getNextCompletedOperation(myOp)` returns the `NdbOperation` object defined after `NdbOperation` *`myOp`*.

Important

This method should only be used after the transaction has been executed, but before the transaction has been closed.

Signature.

```
const NdbOperation* getNextCompletedOperation
    (
      const NdbOperation* op
    ) const
```

Parameters. This method requires a single parameter *op*, which is an operation (`NdbOperation` object), or `NULL`.

Return value. The operation following *op*, or the first operation defined for the transaction if `getNextCompletedOperation()` was called using `NULL`.

2.3.30.19 NdbTransaction::getTransactionId()

Description. This method is used to obtain the transaction ID.

Signature.

```
Uint64 getTransactionId
    (
      void
```

```
    )
```

Parameters. *None*.

Return value. The transaction ID, as an unsigned 64-bit integer.

2.3.30.20 NdbTransaction::insertTuple()

Description. Inserts a tuple using `NdbRecord`.

Signature.

```
const NdbOperation* insertTuple
    (
      const NdbRecord* key_rec,
      const char* key_row,
      const NdbRecord* attr_rec,
      const char* attr_row,
      const unsigned char* mask = 0,
      const NdbOperation::OperationOptions* opts = 0,
      Uint32 sizeOfOptions = 0
    )
```

```
const NdbOperation* insertTuple
    (
      const NdbRecord* combined_rec,
      const char* combined_row,
      const unsigned char* mask = 0,
      const NdbOperation::OperationOptions* opts = 0,
      Uint32 sizeOfOptions = 0
    )
```

Parameters. `insertTuple()` takes the following parameters:

- A pointer to an `NdbRecord` indicating the record (*`key_rec`*) to be inserted.
- A row (*`key_row`*) of data to be inserted.
- A pointer to an `NdbRecord` indicating an attribute (*`attr_rec`*) to be inserted.
- A row (*`attr_row`*) of data to be inserted as the attribute.
- A *`mask`* which can be used to filter the columns to be inserted.
- `OperationOptions` (*`opts`*) can be used to provide more finely-grained control of operation definitions. An `OperationOptions` structure is passed with flags indicating which operation definition options are present. Not all operation types support all operation options; for the options supported by each type of operation, see Section 2.3.30.21, "NdbTransaction::readTuple()".
- The optional *`sizeOfOptions`* parameter is used to preserve backward compatibility of this interface with previous definitions of the `OperationOptions` structure. If an unusual size is detected by the interface implementation, it can use this to determine how to interpret the passed `OperationOptions` structure. To enable this functionality, the caller should pass `sizeof(NdbOperation::OperationOptions)` for the value of this argument.

This method can also be called using a single `NdbRecord` pointer and single `char` pointer (*`combined_rec`*, *`combined_row`*) where the single `NdbRecord` represents record and attribute and data.

Return value. A `const` pointer to the `NdbOperation` representing this insert operation.

2.3.30.21 NdbTransaction::readTuple()

Description. This method reads a tuple using `NdbRecord` objects.

Signature.

```
const NdbOperation* readTuple
    (
      const NdbRecord* key_rec,
      const char* key_row,
      const NdbRecord* result_rec,
      char* result_row,
      NdbOperation::LockMode lock_mode = NdbOperation::LM_Read,
      const unsigned char* result_mask = 0,
      const NdbOperation::OperationOptions* opts = 0,
      Uint32 sizeOfOptions = 0
    )
```

Parameters. This method takes the following parameters:

- *`key_rec`* is a pointer to an `NdbRecord` for either a table or an index. If on a table, then the operation uses a primary key; if on an index, then the operation uses a unique key. In either case, the *`key_rec`* must include all columns of the key.

- The *`key_row`* passed to this method defines the primary or unique key of the affected tuple, and must remain valid until `execute()` is called.

  The mask, if not `NULL`, defines a subset of attributes to read, update, or insert. Only if `(mask[attrId >> 3] & (1<<(attrId & 7)))` is set is the column affected. The mask is copied by the methods, so need not remain valid after the call returns.

- *`result_rec`* is a pointer to an `NdbRecord` used to hold the result

- *`result_row`* defines a buffer for the result data.

- *`lock_mode`* specifies the lock mode in effect for the operation. See Section 2.3.25.15, "NdbOperation::LockMode", for permitted values and other information.

- *`result_mask`* defines a subset of attributes to read. Only if `mask[attrId >> 3] & (1<<(attrId & 7))` is set is the column affected. The mask is copied, and so need not remain valid after the method call returns.

- `OperationOptions` (*`opts`*) can be used to provide more finely-grained control of operation definitions. An `OperationOptions` structure is passed with flags indicating which operation definition options are present. Not all operation types support all operation options; the options supported for each type of operation are shown in the following table:

  Table 2.69 Operation types for NdbTransaction::readTuple() OperationOptions (opts) parameter, with operation options supported by each type

Operation type (Method)	`OperationOptions` Flags Supported
`readTuple()`	`OO_ABORTOPTION`, `OO_GETVALUE`, `OO_PARTITION_ID`, `OO_INTERPRETED`
`insertTuple()`	`OO_ABORTOPTION`, `OO_SETVALUE`, `OO_PARTITION_ID`, `OO_ANYVALUE`
`updateTuple()`	`OO_ABORTOPTION`, `OO_SETVALUE`, `OO_PARTITION_ID`, `OO_INTERPRETED`, `OO_ANYVALUE`
`writeTuple()`	`OO_ABORTOPTION`, `OO_SETVALUE`, `OO_PARTITION_ID`, `OO_ANYVALUE`
`deleteTuple()`	`OO_ABORTOPTION`, `OO_GETVALUE`, `OO_PARTITION_ID`, `OO_INTERPRETED`, `OO_ANYVALUE`

- The optional *`sizeOfOptions`* parameter is used to preserve backward compatibility of this interface with previous definitions of the `OperationOptions` structure. If an unusual size is detected by the interface implementation, it can use this to determine how to interpret the passed OperationOptions structure. To enable this functionality, the caller should pass sizeof(NdbOperation::OperationOptions) for the value of this argument.

Return value. A pointer to the NdbOperation representing this read operation (this can be used to check for errors).

2.3.30.22 NdbTransaction::refresh()

Description. This method updates the transaction's timeout counter, and thus avoids aborting due to transaction timeout.

Note

It is not advisable to take a lock on a record and maintain it for a extended time since this can impact other transactions.

Signature.

```
int refresh
    (
      void
    )
```

Parameters. *None*.

Return value. Returns 0 on success, -1 on failure.

2.3.30.23 NdbTransaction::releaseLockHandle()

Description. This method is used to release a lock handle (see Section 2.3.25.5, “NdbOperation::getLockHandle”) when it is no longer required. For NdbRecord primary key read operations, this cannot be called until the associated read operation has been executed.

Note

All lock handles associated with a given transaction are released when that transaction is closed.

Signature.

```
int releaseLockHandle
    (
      const NdbLockHandle* lockHandle
    )
```

Parameters. The NdbLockHandle object to be released.

Return value. 0 on success.

2.3.30.24 NdbTransaction::scanIndex()

Description. Perform an index range scan of a table, with optional ordering.

Signature.

```
NdbIndexScanOperation* scanIndex
    (
      const NdbRecord* key_record,
      const NdbRecord* result_record,
      NdbOperation::LockMode lock_mode = NdbOperation::LM_Read,
      const unsigned char* result_mask = 0,
      const NdbIndexScanOperation::IndexBound* bound = 0,
      const NdbScanOperation::ScanOptions* options = 0,
```

```
    Uint32 sizeOfOptions = 0
  )
```

Parameters. The *key_record* describes the index to be scanned. It must be a key record for the index; that is, it must specify, at a minimum, all of the key columns of the index. The *key_record* must be created from the index to be scanned (and not from the underlying table).

The *result_record* describes the rows to be returned from the scan. For an ordered index scan, *result_record* must be a key record for the index to be scanned; that is, it must include (at a minimum) all of the columns in the index (the full index key is needed by the NDB API for merge-sorting the ordered rows returned from each fragment).

Like the *key_record*, the result_record must be created from the underlying table, and not from the index to be scanned. Both the *key_record* and *result_record* `NdbRecord` structures must stay in place until the scan operation is closed.

A single `IndexBound` can be specified either in this call or in a separate call to `NdbIndexScanOperation::setBound()`. To perform a multi-range read, the *scan_flags* in the `ScanOptions` structure must include `SF_MULTIRANGE`. Additional bounds can be added using successive calls to `NdbIndexScanOperation::setBound()`.

To specify an equals bound, use the same row pointer for the *low_key* and *high_key* with the low and high inclusive bits set.

To specify additional options, pass a `ScanOptions` structure.

The *sizeOfOptions* exists To enable backward compatability for this interface. This parameter indicates the size of the `ScanOptions` structure at the time the client was compiled, and enables detection of the use of an old-style `ScanOptions` structure. If this functionality is not required, this argument can be left set to 0.

Note

For multi-range scans, the *low_key* and *high_key* pointers must be unique. In other words, it is not permissible to reuse the same row buffer for several different range bounds within a single scan. However, it is permissible to use the same row pointer as *low_key* and *high_key* in order to specify an equals bound; it is also permissible to reuse the rows after the `scanIndex()` method returns—that is, they need not remain valid until `execute()` time (unlike the `NdbRecord` pointers).

Return value. The current `NdbIndexScanOperation`, which can be used for error checking.

2.3.30.25 NdbTransaction::scanTable()

Description. This method performs a table scan, using an `NdbRecord` object to read out column data.

Signature.

```
NdbScanOperation* scanTable
  (
    const NdbRecord* result_record,
    NdbOperation::LockMode lock_mode = NdbOperation::LM_Read,
    const unsigned char* result_mask = 0,
    Uint32 scan_flags = 0,
    Uint32 parallel = 0,
    Uint32 batch = 0
  )
```

Parameters. The `scanTable()` method takes the following parameters:

- A pointer to an `NdbRecord` for storing the result. This *`result_record`* must remain valid until after the `execute()` call has been made.
- The *`lock_mode`* in effect for the operation. See Section 2.3.25.15, "NdbOperation::LockMode", for permitted values and other information.
- The *`result_mask`* pointer is optional. If it is present, only columns for which the corresponding bit (by attribute ID order) in *`result_mask`* is set will be retrieved in the scan. The *`result_mask`* is copied internally, so in contrast to *`result_record`* need not be valid when `execute()` is invoked.
- *`scan_flags`* can be used to impose ordering and sorting conditions for scans. See Section 2.3.29.9, "NdbScanOperation::ScanFlag", for a list of permitted values.
- The *`parallel`* argument is the desired parallelism, or `0` for maximum parallelism (receiving rows from all fragments in parallel), which is the default.
- *`batch`* determines whether batching is employed. The default is 0 (off).

Return value. A pointer to the `NdbScanOperation` representing this scan. The operation can be checked for errors if necessary.

2.3.30.26 NdbTransaction::setMaxPendingBlobReadBytes()

Description. Sets the batch size in bytes for `BLOB` read operations. When the volume of `BLOB` data to be read within a given transaction exceeds this amount, all of the transaction's pending `BLOB` read operations are executed.

Signature.

```
void setMaxPendingBlobReadBytes
    (
      Uint32 bytes
    )
```

Parameters. The batch size, as the number of *`bytes`*. Using 0 causes `BLOB` read batching to be disabled, which is the default behavior (for backward compatibility).

Return value. *None*.

Note

`BLOB` read batching can also be controlled in the mysql client and other MySQL client application using the MySQL Server's `--ndb-blob-read-batch-bytes` option and its associated MySQL Server system variables.

2.3.30.27 NdbTransaction::setMaxPendingBlobWriteBytes()

Description. Sets the batch size in bytes for `BLOB` write operations. When the volume of `BLOB` data to be written within a given transaction exceeds this amount, all of the transaction's pending `BLOB` write operations are executed.

Signature.

```
void setMaxPendingBlobWriteBytes
    (
      Uint32 bytes
    )
```

Parameters. The batch size, as the number of *`bytes`*. Using 0 causes `BLOB` write batching to be disabled, which is the default behavior (for backward compatibility).

Return value. *None*.

Note

BLOB write batching can also be controlled in the mysql client and other MySQL client application using the MySQL Server's --ndb-blob-write-batch-bytes option and its associated MySQL Server system variables.

2.3.30.28 NdbTransaction::setSchemaObjectOwnerChecks()

Description. Enables or disables a schema object ownership check when multiple Ndb_cluster_connection objects are in use. When this check is enabled, objects used by this transaction are checked to make sure that they belong to the NdbDictionary owned by this connection. This is done by acquiring the schema objects of the same names from the connection and comparing these with the schema objects passed to the transaction. If they do not match, an error is returned.

This method is available for debugging purposes beginning with NDB 7.3.9 and NDB 7.4.4. (Bug #19875977) You should be aware that enabling this check carries a performance penalty and for this reason you should avoid doing so in a production setting.

Signature.

```
void setSchemaObjOwnerChecks
    (
      bool runChecks
    )
```

Parameters. A single parameter *runChecks*. Use true to enable ownership checks, false to disable them.

Return value. *None*.

2.3.30.29 NdbTransaction::unlock()

Description. This method creates an unlock operation on the current transaction; when executed, the unlock operation removes the lock referenced by the NdbLockHandle (see Section 2.3.25.5, “NdbOperation::getLockHandle”) passed to the method.

Signature.

```
const NdbOperation* unlock
    (
      const NdbLockHandle* lockHandle,
      NdbOperation::AbortOption ao = NdbOperation::DefaultAbortOption
    )
```

Parameters. A pointer to a lock handle; in addition, optionally, an AbortOption value *ao*.

In the event that the unlock operation fails—for example, due to the row already being unlocked—the AbortOption specifies how this is handled, the default being that errors cause transactions to abort.

Return value. A pointer to an NdbOperation (the unlock operation created).

2.3.30.30 NdbTransaction::updateTuple()

Description. Updates a tuple using an NdbRecord object.

Signature.

```
const NdbOperation* updateTuple
    (
      const NdbRecord* key_rec,
      const char* key_row,
      const NdbRecord* attr_rec,
      const char* attr_row,
```

```
        const unsigned char* mask = 0,
        const NdbOperation::OperationOptions* opts = 0,
        Uint32 sizeOfOptions = 0
    )
```

Parameters. `updateTuple()` takes the following parameters:

- *`key_rec`* is a pointer to an `NdbRecord` for either a table or an index. If on a table, then the operation uses a primary key; if on an index, then the operation uses a unique key. In either case, the *`key_rec`* must include all columns of the key.

- The *`key_row`* passed to this method defines the primary or unique key of the affected tuple, and must remain valid until `execute()` is called.

- *`attr_rec`* is an `NdbRecord` referencing the attribute to be updated.

> **Note**
>
> For unique index operations, the *`attr_rec`* must refer to the underlying table of the index, not to the index itself.

- *`attr_row`* is a buffer containing the new data for the update.

- The *`mask`*, if not `NULL`, defines a subset of attributes to be updated. The mask is copied, and so does not need to remain valid after the call to this method returns.

- `OperationOptions` (*`opts`*) can be used to provide more finely-grained control of operation definitions. An `OperationOptions` structure is passed with flags indicating which operation definition options are present. Not all operation types support all operation options; for the options supported by each type of operation, see Section 2.3.30.21, "NdbTransaction::readTuple()".

- The optional *`sizeOfOptions`* parameter is used to preserve backward compatibility of this interface with previous definitions of the `OperationOptions` structure. If an unusual size is detected by the interface implementation, it can use this to determine how to interpret the passed `OperationOptions` structure. To enable this functionality, the caller should pass `sizeof(NdbOperation::OperationOptions)` for the value of this argument.

Return value. The `NdbOperation` representing this operation (can be used to check for errors).

2.3.30.31 NdbTransaction::writeTuple()

Description. This method is used with `NdbRecord` to write a tuple of data.

Signature.

```
const NdbOperation* writeTuple
    (
        const NdbRecord* key_rec,
        const char* key_row,
        const NdbRecord* attr_rec,
        const char* attr_row,
        const unsigned char* mask = 0,
        const NdbOperation::OperationOptions* opts = 0,
        Uint32 sizeOfOptions = 0
    )
```

Parameters. This method takes the following parameters:

- *`key_rec`* is a pointer to an `NdbRecord` for either a table or an index. If on a table, then the operation uses a primary key; if on an index, then the operation uses a unique key. In either case, the *`key_rec`* must include all columns of the key.

- The *`key_row`* passed to this method defines the primary or unique key of the tuple to be written, and must remain valid until `execute()` is called.

- *attr_rec* is an `NdbRecord` referencing the attribute to be written.

Note

For unique index operations, the *attr_rec* must refer to the underlying table of the index, not to the index itself.

- *attr_row* is a buffer containing the new data.
- The *mask*, if not `NULL`, defines a subset of attributes to be written. The mask is copied, and so does not need to remain valid after the call to this method returns.
- `OperationOptions` (*opts*) can be used to provide more finely-grained control of operation definitions. An `OperationOptions` structure is passed with flags indicating which operation definition options are present. Not all operation types support all operation options; for the options supported by each type of operation, see Section 2.3.30.21, “NdbTransaction::readTuple()”.
- The optional *sizeOfOptions* parameter is used to provide backward compatibility of this interface with previous definitions of the `OperationOptions` structure. If an unusual size is detected by the interface implementation, it can use this to determine how to interpret the passed `OperationOptions` structure. To enable this functionality, the caller should pass `sizeof(NdbOperation::OperationOptions)` for the value of this argument.

Return value. A `const` pointer to the `NdbOperation` representing this write operation. The operation can be checked for errors if and as necessary.

2.3.31 The Object Class

This class provides meta-information about database objects such as tables and indexes. `Object` subclasses model these and other database objects.

Parent class. `NdbDictionary`

Child classes. `Datafile`, `Event`, `Index`, `LogfileGroup`, `Table`, `Tablespace`, `Undofile`, `HashMap`, `ForeignKey`

Methods. The following table lists the public methods of the `Object` class and the purpose or use of each method:

Table 2.70 Object class methods and descriptions

Name	Description
`getObjectId()`	Gets an object's ID
`getObjectStatus()`	Gets an object's status
`getObjectVersion()`	Gets the version of an object

Note

All 3 of these methods are pure virtual methods, and are reimplemented in the `Table`, `Index`, and `Event` subclasses where needed.

Types. These are the public types of the `Object` class:

Table 2.71 Object class types and descriptions

Name	Description
`FragmentType`	Fragmentation type used by the object (a table or index)

Name	Description
`State`	The object's state (whether it is usable)
`Status`	The object's state (whether it is available)
`Store`	Whether the object has been temporarily or permanently stored
`Type`	The object's type (what sort of table, index, or other database object the `Object` represents)

2.3.31.1 Object::FragmentType

This type describes the `Object`'s fragmentation type.

Description. This parameter specifies how data in the table or index is distributed among the cluster's storage nodes, that is, the number of fragments per node. The larger the table, the larger the number of fragments that should be used. Note that all replicas count as a single fragment. For a table, the default is `FragAllMedium`. For a unique hash index, the default is taken from the underlying table and cannot currently be changed.

Enumeration values. Possible values for `FragmentType` are shown, along with descriptions, in the following table:

Table 2.72 FragmentType values and descriptions

Name	Description
`FragUndefined`	The fragmentation type is undefined or the default
`FragAllMedium`	Two fragments per node
`FragAllLarge`	Four fragments per node
`DistrKeyHash`	Distributed hash key
`DistrKeyLin`	Distributed linear hash key
`UserDefined`	User defined
`HashMapPartition`	Hash map partition

2.3.31.2 Object::PartitionBalance

Description. This type enumerates provides partition balance settings (fragment count types) from which to choose when using `setPartitionBalance()`. This is also the type returned by `getPartitionBalance()`

Enumeration values. Possible values for `PartitionBalance` are shown, along with descriptions, in the following table:

Table 2.73 Object::PartitionBalance data type values and descriptions

Name	Description
`PartitionBalance_ForRPByLDM`	Use one fragment per LDM per node
`PartitionBalance_ForRAByLDM`	Use one fragment per LDM per node group
`PartitionBalance_ForRPByNode`	Use one fragment per node
`PartitionBalance_ForRAByNode`	Use one fragment per node group
`PartitionBalance_Specific`	Use setting determined by `setPartitionBalance()`

Prior to NDB 7.5.4, this was known as `FragmentCountType`, and could take one of the values `FragmentCount_OnePerLDMPerNode`, `FragmentCount_OnePerLDMPerNodeGroup`, `FragmentCount_OnePerNode`, `FragmentCount_OnePerNodeGroup`, or `FragmentCount_Specific`. These values correspond to those shown in the previous table, in the order shown.

2.3.31.3 Object::State

This type describes the state of the `Object`.

Description. This parameter provides us with the object's state. By *state*, we mean whether or not the object is defined and is in a usable condition.

Enumeration values. Possible values for `State` are shown, along with descriptions, in the following table:

Table 2.74 Object State type values and descriptions

Name	Description
`StateUndefined`	Undefined
`StateOffline`	Offline, not useable
`StateBuilding`	Building (e.g. restore?), not useable(?)
`StateDropping`	Going offline or being dropped; not usable
`StateOnline`	Online, usable
`StateBackup`	Online, being backed up, usable
`StateBroken`	Broken; should be dropped and re-created

2.3.31.4 Object::Status

This type describes the `Object`'s status.

Description. Reading an object's `Status` tells whether or not it is available in the `NDB` kernel.

Enumeration values. Possible values for `Status` are shown, along with descriptions, in the following table:

Table 2.75 Object Status data type values and descriptions

Name	Description
`New`	The object exists only in memory, and has not yet been created in the `NDB` kernel
`Changed`	The object has been modified in memory, and must be committed in the `NDB` Kernel for changes to take effect
`Retrieved`	The object exists, and has been read into main memory from the `NDB` Kernel
`Invalid`	The object has been invalidated, and should no longer be used
`Altered`	The table has been altered in the `NDB` kernel, but is still available for use

2.3.31.5 Object::Store

This type describes the `Object`'s persistence.

Description. Reading this value tells us is the object is temporary or permanent.

Enumeration values. Possible values for `Store` are shown, along with descriptions, in the following table:

Table 2.76 Object Store data type values and descriptions

Name	Description
`StoreUndefined`	The object is undefined
`StoreTemporary`	Temporary storage; the object or data will be deleted on system restart
`StorePermanent`	The object or data is permanent; it has been logged to disk

2.3.31.6 Object::Type

This type describes the type of the `Object`.

Description. The `Type` of the object can be one of several different sorts of index, trigger, tablespace, and so on.

Enumeration values. Possible values for `Type` are shown, along with descriptions, in the following table:

Table 2.77 Object Type data type values and descriptions

Name	Description
`TypeUndefined`	Undefined
`SystemTable`	System table
`UserTable`	User table (may be temporary)
`UniqueHashIndex`	Unique (but unordered) hash index
`OrderedIndex`	Ordered (but not unique) index
`HashIndexTrigger`	Index maintenance (*internal*)
`IndexTrigger`	Index maintenance (*internal*)
`SubscriptionTrigger`	Backup or replication (*internal*)
`ReadOnlyConstraint`	Trigger (*internal*)
`Tablespace`	Tablespace
`LogfileGroup`	Logfile group
`Datafile`	Datafile
`Undofile`	Undofile
`ReorgTrigger`	Trigger
`HashMap`	Hash map
`ForeignKey`	Foreign key
`FKParentTrigger`	Trigger on a foreign key's parent table
`FKChildTrigger`	Trigger on a foreign key's child table

`ForeignKey`, `FKParentTrigger`, and `FKChildTrigger` were added in NDB Cluster 7.3. See Section 2.3.8, “The ForeignKey Class”.

2.3.31.7 Object::getObjectId()

Description. This method retrieves the object's ID.

Signature.

```
virtual int getObjectId
    (
      void
    ) const
```

Parameters. *None*.

Return value. The object ID, an integer.

2.3.31.8 Object::getObjectStatus()

Description. This method retrieves the status of the object for which it is invoked.

Signature.

```
virtual Status getObjectStatus
    (
      void
    ) const
```

Parameters. *None*.

Return value. Returns the current `Status` of the `Object`.

2.3.31.9 Object::getObjectVersion()

Description. The method gets the current version of the object.

Signature.

```
virtual int getObjectVersion
    (
      void
    ) const
```

Parameters. *None*.

Return value. The object's version number, an integer.

2.3.32 The OperationOptions Structure

Parent class. `NdbOperation`

Description. These options are passed to the `NdbRecord`-based primary key and scan takeover operation methods defined in the `NdbTransaction` and `NdbScanOperation` classes.

Note

Most `NdbTransaction::*Tuple()` methods (see Section 2.3.30, "The NdbTransaction Class") take a supplementary *`sizeOfOptions`* parameter. This is optional, and is intended to permit the interface implementation to remain backward compatible with older un-recompiled clients that may pass an older (smaller) version of the `OperationOptions` structure. This effect is achieved by passing `sizeof(OperationOptions)` into this parameter.

Each option type is marked as present by setting the corresponding bit in *`optionsPresent`*. (Only the option types marked in *`optionsPresent`* need have sensible data.) All data is copied out of the `OperationOptions` structure (and any subtended structures) at operation definition time. If no options are required, then `NULL` may be passed instead.

Members. The elements making up this structure are shown in the following table:

Table 2.78 NdbOperation::OperationOptions structure member names, types, and description

Name	Type	Description
optionsPresent	Uint64	Which flags are present.
[...]	Flags: The accepted names and values are shown in the following list: • OO_ABORTOPTION: 0x01 • OO_GETVALUE: 0x02 • OO_SETVALUE: 0x04 • OO_PARTITION_ID: 0x08 • OO_INTERPRETED: 0x10 • OO_ANYVALUE: 0x20 • OO_CUSTOMDATA: 0x40 • OO_LOCKHANDLE: 0x80 • OO_QUEUABLE 0x100 • OO_NOT_QUEUABLE 0x200 • OO_DEFERRED_CONSTAINTS 0x400 • OO_DISABLE_FK 0x800 • OO_NOWAIT 0x1000	Type of flags.
abortOption	AbortOption	An operation-specific abort option; necessary only if the default abortoption behavior is not satisfactory.
extraGetValues	GetValueSpec	Extra column values to be read.
numExtraGetValues	Uint32	Number of extra column values to be read.
extraSetValues	SetValueSpec	Extra column values to be set.
numExtraSetValues	Uint32	Number of extra column values to be set.

Name	Type	Description
partitionId	Uint32	Limit the scan to the partition having this ID; alternatively, you can supply an PartitionSpec here. For index scans, partitioning information can be supplied for each range.
interpretedCode	NdbInterpretedCode	Interpeted code to execute as part of the scan.
anyValue	Uint32	An anyValue to be used with this operation. This is used by NDB Cluster Replication to store the SQL node's server ID. By starting the SQL node with the --server-id-bits option (which causes only some of the server_id's bits to be used for uniquely identifying it) set to less than 32, the remaining bits can be used to store user data.
customData	void*	Data pointer to associate with this operation.
partitionInfo	PartitionSpec	Partition information for bounding this scan.
sizeOfPartInfo	Uint32	Size of the bounding partition information.

For more information, see Section 2.3.27, “The NdbRecord Interface”.

2.3.33 The PartitionSpec Structure

This section describes the PartitionSpec structure.

Parent class. Ndb

Description. A PartitionSpec is used for describing a table partition in terms of any one of the following criteria:

- A specific partition ID for a table with user-defined partitioning.
- An array made up of a table's distribution key values for a table with native partitioning.
- A row in NdbRecord format containing a natively partitioned table's distribution key values.

Attributes. A PartitionSpec has two attributes, a SpecType and a Spec which is a data structure corresponding to that SpecType, as shown in the following table:

Table 2.79 PartitionSpec attributes with the SpecType values, data structures, and descriptions for each attribute.

SpecType Enumeration	SpecType Value (Uint32)	Data Structure	Description
PS_NONE	0	*none*	No partitioning information is provided.
PS_USER_DEFINED	1	UserDefined	For a table having user-defined partitioning, a specific partition is identified by its partition ID.
PS_DISTR_KEY_PART_PTR	2	KeyPartPtr	For a table having native partitioning, an array containing the table's distribution key values is used to identify the partition.
PS_DISTR_KEY_RECORD	3	KeyRecord	The partition is identified using a natively partitioned table's distribution key values,

SpecType Enumeration	SpecType Value (Uint32)	Data Structure	Description
			as contained in a row given in NdbRecord format.

UserDefined structure. This structure is used when the SpecType is PS_USER_DEFINED.

Table 2.80 Attribute types of the partitionId attribute of the PS_USER_DEFINED SpecType

Attribute	Type	Description
partitionId	Uint32	The partition ID for the desired table.

KeyPartPtr structure. This structure is used when the SpecType is PS_DISTR_KEY_PART_PTR.

Table 2.81 Attributes of the PS_DISTR_KEY_PART_PTR SpecType, with attribute types and descriptions

Attribute	Type	Description
tableKeyParts	Key_part_ptr	Pointer to the distribution key values for a table having native partitioning.
xfrmbuf	void*	Pointer to a temporary buffer used for performing calculations.
xfrmbuflen	Uint32	Length of the temporary buffer.

KeyRecord structure. This structure is used when the SpecType is PS_DISTR_KEY_RECORD.

Table 2.82 PS_DISTR_KEY_RECORD SpecType attributes, with attribute types and descriptions

Attribute	Type	Description
keyRecord	NdbRecord	A row in NdbRecord format, containing a table's distribution keys.
keyRow	const char*	The distribution key data.
xfrmbuf	void*	Pointer to a temporary buffer used for performing calculations.
xfrmbuflen	Uint32	Length of the temporary buffer.

Definition from Ndb.hpp. Because this is a fairly complex structure, we here provide the original source-code definition of PartitionSpec, as given in storage/ndb/include/ndbapi/Ndb.hpp:

```
struct PartitionSpec
{
  enum SpecType
  {
    PS_NONE                = 0,
    PS_USER_DEFINED        = 1,
    PS_DISTR_KEY_PART_PTR  = 2,
    PS_DISTR_KEY_RECORD    = 3
  };

  Uint32 type;

  union
  {
    struct {
      Uint32 partitionId;
    } UserDefined;
```

```
    struct {
      const Key_part_ptr* tableKeyParts;
      void* xfrmbuf;
      Uint32 xfrmbuflen;
    } KeyPartPtr;

    struct {
      const NdbRecord* keyRecord;
      const char* keyRow;
      void* xfrmbuf;
      Uint32 xfrmbuflen;
    } KeyRecord;
  };
};
```

2.3.34 The RecordSpecification Structure

Parent class. NdbDictionary

Description. This structure is used to specify columns and range offsets when creating NdbRecord objects.

Members. The elements making up this structure are shown in the following table:

Table 2.83 NdbDictionary::RecordSpecification attributes, with types and descriptions

Name	Type	Description
column	Column	The column described by this entry (the column's maximum size defines the field size for the row). Even when creating an NdbRecord for an index, this must point to a column obtained from the underlying table, and not from the index itself.
offset	Uint32	The offset of data from the beginning of a row. For reading blobs, the blob handle (NdbBlob), rather than the actual blob data, is written into the row. This means that there must be at least sizeof(NdbBlob*) must be available in the row.
nullbit_byte_offset	Uint32	The offset from the beginning of the row of the byte containing the NULL bit.
nullbit_bit_in_byte	Uint32	NULL bit (0-7).

Important

nullbit_byte_offset and nullbit_bit_in_byte are not used for non-NULLable columns.

For more information, see Section 2.3.27, "The NdbRecord Interface".

2.3.35 The ScanOptions Structure

Parent class. NdbScanOperation

Description. This data structure is used to pass options to the NdbRecord-based scanTable() and scanIndex() methods of the NdbTransaction class. Each option type is marked as present by setting the corresponding bit in the `optionsPresent` field. Only the option types marked in the `optionsPresent` field need have sensible data.

All data is copied out of the `ScanOptions` structure (and any subtended structures) at operation definition time. If no options are required, then `NULL` may be passed as the `ScanOptions` pointer.

Members. The elements making up this structure are shown in the following table:

Table 2.84 NdbScanOperation::ScanOptions attributes, with types and descriptions

Name	Type	Description
`optionsPresent`	`Uint64`	Which options are present.
[...]	`Type`: • `SO_SCANFLAGS`: `0x01` • `SO_PARALLEL`: `0x02` • `SO_BATCH`: `0x04` • `SO_GETVALUE`: `0x08` • `SO_PARTITION_ID`: `0x10` • `SO_INTERPRETED`: `0x20` • `SO_CUSTOMDATA`: `0x40` • `SO_PARTINFO`: `0x80`	Type of options.
`scan_flags`	`Uint32`	Flags controlling scan behavior; see Section 2.3.29.9, “NdbScanOperation::ScanFlag”, for more information.
`parallel`	`Uint32`	Scan parallelism; 0 (the default) sets maximum parallelism.
`batch`	`Uint32`	Batch size for transfers from data nodes to API nodes; 0 (the default) enables this to be selected automatically.
`extraGetValues`	`GetValueSpec`	Extra values to be read for each row matching the sdcan criteria.
`numExtraGetValues`	`Uint32`	Number of extra values to be read.
`partitionId`	`Uint32`	Limit the scan to the partition having this ID; alternatively, you can supply an `PartitionSpec` here. For index scans, partitioning information can be supplied for each range.
`interpretedCode`	`NdbInterpretedCode`	Interpeted code to execute as part of the scan.
`customData`	`void*`	Data pointer to associate with this scan operation.
`partitionInfo`	`PartitionSpec`	Partition information for bounding this scan.

Name	Type	Description
sizeOfPartInfo	Uint32	Size of the bounding partition information.

For more information, see Section 2.3.27, "The NdbRecord Interface".

2.3.36 The SetValueSpec Structure

Parent class. NdbOperation

Description. This structure is used to specify an extra value to set as part of an NdbRecord operation.

Members. The elements making up this structure are shown in the following table:

Table 2.85 NdbOperation::SetValueSpec attributes, with types and descriptions

Name	Type	Description
column	Column	To specify an extra value to read, the caller must provide this, as well as (optionally NULL) *appStorage* pointer.
value	void*	This must point to the value to be set, or to NULL if the attribute is to be set to NULL. The value pointed to is copied when the operation is defined, and need not remain in place until execution time.

Important

Currently, blob values cannot be set using SetValueSpec.

For more information, see Section 2.3.27, "The NdbRecord Interface".

2.3.37 The Table Class

This section describes the Table class, which models a database table in the NDB API.

Parent class. NdbDictionary

Child classes. *None*

Description. The Table class represents a table in an NDB Cluster database. This class extends the Object class, which in turn is an inner class of the NdbDictionary class.

Important

It is possible using the NDB API to create tables independently of the MySQL server. However, it is usually not advisable to do so, since tables created in this fashion cannot be seen by the MySQL server. Similarly, it is possible using Table methods to modify existing tables, but these changes (except for renaming tables) are not visible to MySQL.

Calculating Table Sizes. When calculating the data storage one should add the size of all attributes (each attribute consuming a minimum of 4 bytes) and well as 12 bytes overhead. Variable size attributes have a size of 12 bytes plus the actual data storage parts, with an additional overhead based on the size of the variable part. For example, consider a table with 5 attributes: one 64-bit attribute, one 32-bit attribute, two 16-bit attributes, and one array of 64 8-bit attributes. The amount of memory consumed per record by this table is the sum of the following:

- 8 bytes for the 64-bit attribute
- 4 bytes for the 32-bit attribute
- 8 bytes for the two 16-bit attributes, each of these taking up 4 bytes due to right-alignment
- 64 bytes for the array (64 * 1 byte per array element)
- 12 bytes overhead

This totals 96 bytes per record. In addition, you should assume an overhead of about 2% for the allocation of page headers and wasted space. Thus, 1 million records should consume 96 MB, and the additional page header and other overhead comes to approximately 2 MB. Rounding up yields 100 MB.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.86 Table class methods and descriptions

Name	Description
`Table()`	Class constructor
`~Table()`	Destructor
`addColumn()`	Adds a column to the table
`aggregate()`	Computes aggregate data for the table
`equal()`	Compares the table with another table
`getColumn()`	Gets a column (by name) from the table
`getDefaultNoPartitionsFlag()`	Checks whether the default number of partitions is being used
`getFragmentCount()`	Gets the number of fragments for this table
`getExtraMetadata()`	Gets extra metadata for this table
`getFragmentData()`	Gets table fragment data (ID, state, and node group)
`getFragmentDataLen()`	Gets the length of the table fragment data
`getFragmentNodes()`	Gets IDs of data nodes on which fragments are located
`getFragmentType()`	Gets the table's `FragmentType`
`getFrmData()`	Gets the data from the table `.FRM` file
`getFrmLength()`	Gets the length of the table's `.FRM` file
`getHashMap()`	Gets the table's hash map.
`getKValue()`	Gets the table's `KValue`
`getLinearFlag()`	Gets the current setting for the table's linear hashing flag
`getLogging()`	Checks whether logging to disk is enabled for this table
`getMaxLoadFactor()`	Gets the table's maximum load factor
`getMaxRows()`	Gets the maximum number of rows that this table may contain
`getMinLoadFactor()`	Gets the table's minimum load factor
`getName()`	Gets the table's name
`getNoOfColumns()`	Gets the number of columns in the table
`getNoOfPrimaryKeys()`	Gets the number of columns in the table's primary key.
`getObjectId()`	Gets the table's object ID
`getObjectStatus()`	Gets the table's object status

Name	Description
getObjectType()	Removed in NDB 7.5.0 (Bug #47960, Bug #11756088)
getObjectVersion()	Gets the table's object version
getPartitionBalance()	Gets partition balance (fragment count type) used for this table (NDB 7.5.4 and later)
getPartitionBalanceString()	Gets partition balance used for this table, as a string (NDB 7.5.4 and later)
getPartitionId()	Gets a partition ID from a hash value
getPrimaryKey()	Gets the name of the table's primary key
getRangeListData()	Gets a RANGE or LIST array
getRangeListDataLen()	Gets the length of the table RANGE or LIST array
getRowChecksumIndicator()	Checks whether the row checksum indicator has been set
getRowGCIIndicator()	Checks whether the row GCI indicator has been set
getSingleUserMode()	Gets the SingleUserMode for this table
getTableId()	Gets the table's ID
getTablespace()	Gets the tablespace containing this table
getTablespaceData()	Gets the ID and version of the tablespace containing the table
getTablespaceDataLen()	Gets the length of the table's tablespace data
getTablespaceNames()	Gets the names of the tablespaces used in the table fragments
hasDefaultValues()	Determine whether table has any columns using default values
setDefaultNoPartitionsFlag()	Toggles whether the default number of partitions should be used for the table
setExtraMetadata()	Sets extra metadata for this table
getFragmentCount()	Gets the number of fragments for this table
setFragmentData()	Sets the fragment ID, node group ID, and fragment state
setFragmentType()	Sets the table's FragmentType
setFrm()	Sets the .FRM file to be used for this table
setHashMap()	Sets the table's hash map.
setKValue()	Set the KValue
setLinearFlag()	Sets the table's linear hashing flag
setLogging()	Toggle logging of the table to disk
setMaxLoadFactor()	Set the table's maximum load factor (MaxLoadFactor)
setMaxRows()	Sets the maximum number of rows in the table
setMinLoadFactor()	Set the table's minimum load factor (MinLoadFactor)
setPartitionBalance()	Sets the partition balance (fragment count type) for this table (NDB 7.5.4 and later)
setName()	Sets the table's name
setObjectType()	Removed in NDB 7.5.0 (Bug #47960, Bug #11756088)
setRangeListData()	Sets LIST and RANGE partition data

Name	Description
setRowChecksumIndicator()	Sets the row checksum indicator
setRowGCIIndicator()	Sets the row GCI indicator
setSingleUserMode()	Sets the SingleUserMode value for this table
setStatusInvalid()	
setTablespace()	Set the tablespace to use for this table
setTablespaceData()	Sets the tablespace ID and version
setTablespaceNames()	Sets the tablespace names for fragments
validate()	Validates the definition for a new table prior to creating it

The assignment (=) operator is overloaded for this class, so that it always performs a deep copy.

Note

As with other database objects, Table object creation and attribute changes to existing tables done using the NDB API are not visible from MySQL. For example, if you add a new column to a table using Table::addColumn(), MySQL cannot see the new column. The only exception to this rule with regard to tables is that a change of name of an existing NDB table using Table::setName() is visible to MySQL.

Types. The Table class defines a single public type SingleUserMode.

2.3.37.1 Table::addColumn()

Description. Adds a column to a table.

Signature.

```
void addColumn
    (
      const Column& column
    )
```

Parameters. A reference to the column which is to be added to the table.

Return value. *None*; however, it does create a copy of the original Column object.

2.3.37.2 Table::aggregate()

Description. This method computes aggregate data for the table. It is required in order for aggregate methods such as getNoOfPrimaryKeys() to work properly before the table has been created and retrieved via getTableId().

Note

This method was added in MySQL 5.1.12 (see Bug #21690).

Signature.

```
int aggregate
    (
      struct NdbError& error
    )
```

Parameters. A reference to an NdbError object.

Return value. An integer, whose value is `0` on success, and `-1` if the table is in an inconsistent state. In the latter case, the *`error`* is also set.

2.3.37.3 Table Constructor

Description. Creates a `Table` instance. There are two versions of the `Table` constructor, one for creating a new instance, and a copy constructor.

> **Important**
>
> Tables created in the NDB API using this method are not accessible from MySQL.

Signature. New instance:

```
Table
    (
      const char* name = ""
    )
```

Copy constructor:

```
Table
    (
      const Table& table
    )
```

Parameters. For a new instance, the name of the table to be created. For a copy, a reference to the table to be copied.

Return value. A `Table` object.

Destructor.

```
virtual ~Table()
```

2.3.37.4 Table::equal()

Description. This method is used to compare one instance of `Table` with another.

Signature.

```
bool equal
    (
      const Table& table
    ) const
```

Parameters. A reference to the `Table` object with which the current instance is to be compared.

Return value. `true` if the two tables are the same, otherwise `false`.

2.3.37.5 Table::getColumn()

Description. This method is used to obtain a column definition, given either the index or the name of the column.

Signature. This method can be invoked using either the column ID or column name, as shown here:

```
Column* getColumn
    (
      const int AttributeId
    )
```

```
Column* getColumn
    (
      const char* name
    )
```

Parameters. Either of: the column's index in the table (as it would be returned by the column's `getColumnNo()` method), or the name of the column.

Return value. A pointer to the column with the specified index or name. If there is no such column, then this method returns `NULL`.

2.3.37.6 Table::getDefaultNoPartitionsFlag()

Description. This method is used to find out whether the default number of partitions is used for the table.

Signature.

```
Uint32 getDefaultNoPartitionsFlag
    (
      void
    ) const
```

Parameters. *None*.

Return value. A 32-bit unsigned integer.

2.3.37.7 Table::getExtraMetadata()

Description. Get and unpack extra metadata for this `Table`.

Signature.

```
int getExtraMetadata
    (
      Uint32& version,
      void** data,
      Uint32* length
    ) const
```

Parameters. This method takes the following three parameters:

- *`version`*: By convention, as used in NDB Cluster code, `1` means that the extra metadata contains a `.frm` file (`BLOB`) as in NDB 7.6 and earlier; `2` indicates that it is serialized dictionary information as in NDB 8.0. The values are actually arbitrary, and application-specific.

- *`data`*: The stored data retrieved as metadata.

- *`length`*: The length of the stored data (metadata).

Return value. Returns `0` on success, any other value on failure. A nonzer4o value should be interpreted as an error code for the type of error.

This method was added in NDB 8.0.13.

2.3.37.8 Table::getFragmentCount()

Description. This method gets the number of fragments in the table.

Signature.

```
Uint32 getFragmentCount
    (
```

```
      void
    ) const
```

Parameters. *None*.

Return value. The number of table fragments, as a 32-bit unsigned integer.

2.3.37.9 Table::getFragmentData()

Description. This method gets the table's fragment data (ID, state, and node group).

Signature.

```
const void* getFragmentData
    (
      void
    ) const
```

Parameters. *None*.

Return value. A pointer to the data to be read.

2.3.37.10 Table::getFragmentDataLen()

Description. Gets the length of the table fragment data to be read, in bytes.

Signature.

```
Uint32 getFragmentDataLen
    (
      void
    ) const
```

Parameters. *None*.

Return value. The number of bytes to be read, as an unsigned 32-bit integer.

2.3.37.11 Table::getFragmentNodes()

Description. This method retrieves a list of nodes storing a given fragment.

Signature.

```
Uint32 getFragmentNodes
    (
      Uint32 fragmentId,
      Uint32* nodeIdArrayPtr,
      Uint32 arraySize
    ) const
```

Parameters. This method takes the following three parameters:

- *`fragmentId`*: The ID of the desired fragment.
- *`nodeIdArrayPtr`*: Pointer to an array of node IDs of the nodes containing this fragment.

> **Note**
>
> Normally, the primary fragment is entry 0 in this array.

- *`arraySize`*: The size of the array containing the node IDs. If this is less than the number of fragments, then only the first *`arraySize`* entries are written to this array.

Return value. A return value of `0` indicates an error; otherwise, this is the number of table fragments, as a 32-bit unsigned integer.

2.3.37.12 Table::getFragmentType()

Description. This method gets the table's fragmentation type.

Signature.

```
FragmentType getFragmentType
    (
      void
    ) const
```

Parameters. *None*.

Return value. A `FragmentType` value, as defined in Section 2.3.31.1, “Object::FragmentType”.

2.3.37.13 Table::getFrmData()

Description. The the data from the `.FRM` file associated with the table.

Signature.

```
const void* getFrmData
    (
      void
    ) const
```

Parameters. *None*.

Return value. A pointer to the `.FRM` data.

2.3.37.14 Table::getFrmLength()

Description. Gets the length of the table's `.FRM` file data, in bytes.

Signature.

```
Uint32 getFrmLength
    (
      void
    ) const
```

Parameters. *None*.

Return value. The length of the `.FRM` file data (an unsigned 32-bit integer).

2.3.37.15 Table::getHashMap()

Description. Get the hash map used for this table.

Signature.

```
bool getHashMap
    (
      Uint32* id = 0,
      Uint32* version = 0
    ) const
```

Parameters. The table ID and version.

Return value. True if the table has a hash map, otherwise false.

2.3.37.16 Table::getKValue()

Description. This method gets the KValue, a hashing parameter which is currently restricted to the value 6. In a future release, it may become feasible to set this parameter to other values.

Signature.

```
int getKValue
    (
      void
    ) const
```

Parameters. *None*.

Return value. An integer (currently always 6).

2.3.37.17 Table::getLinearFlag()

Description. This method retrieves the value of the table's linear hashing flag.

Signature.

```
bool getLinearFlag
    (
      void
    ) const
```

Parameters. *None*.

Return value. `true` if the flag is set, and `false` if it is not.

2.3.37.18 Table::getLogging()

Description. This class is used to check whether a table is logged to disk—that is, whether it is permanent or temporary.

Signature.

```
bool getLogging
    (
      void
    ) const
```

Parameters. *None*.

Return value. Returns a Boolean value. If this method returns `true`, then full checkpointing and logging are done on the table. If `false`, then the table is a temporary table and is not logged to disk; in the event of a system restart the table still exists and retains its definition, but it will be empty. The default logging value is `true`.

2.3.37.19 Table::getMaxLoadFactor()

Description. This method returns the load factor (a hashing parameter) when splitting of the containers in the local hash tables begins.

Signature.

```
int getMaxLoadFactor
    (
      void
    ) const
```

Parameters. *None*.

Return value. An integer whose maximum value is 100. When the maximum value is returned, this means that memory usage is optimised. Smaller values indicate that less data is stored in each container, which means that keys are found more quickly; however, this also consumes more memory.

2.3.37.20 Table::getMaxRows()

Description. This method gets the maximum number of rows that the table can hold. This is used for calculating the number of partitions.

Signature.

```
Uint64 getMaxRows
    (
      void
    ) const
```

Parameters. *None*.

Return value. The maximum number of table rows, as a 64-bit unsigned integer.

2.3.37.21 Table::getMinLoadFactor()

Description. This method gets the value of the load factor when reduction of the hash table begins. This should always be less than the value returned by `getMaxLoadFactor()`.

Signature.

```
int getMinLoadFactor
    (
      void
    ) const
```

Parameters. *None*.

Return value. An integer (actually, a percentage expressed as an integer; see Section 2.3.37.19, "Table::getMaxLoadFactor()").

2.3.37.22 Table:getName()

Description. Gets the name of a table.

Signature.

```
const char* getName
    (
      void
    ) const
```

Parameters. *None*.

Return value. The name of the table (a string).

2.3.37.23 Table::getNoOfColumns()

Description. This method is used to obtain the number of columns in a table.

Signature.

```
int getNoOfColumns
    (
      void
    ) const
```

Parameters. *None*.

Return value. An integer representing the number of columns in the table.

2.3.37.24 Table::getNoOfPrimaryKeys()

Description. This method finds the number of primary key columns in the table.

Signature.

```
int getNoOfPrimaryKeys
    (
      void
    ) const
```

Parameters. *None*.

Return value. An integer representing the number of primary key columns in the table.

2.3.37.25 Table::getObjectId()

Description. This method gets the table's object ID.

Signature.

```
virtual int getObjectId
    (
      void
    ) const
```

Parameters. *None*.

Return value. The object ID is returned as an integer.

2.3.37.26 Table::getObjectStatus()

Description. This method gets the table's status—that is, its `Object::Status`.

Signature.

```
virtual Object::Status getObjectStatus
    (
      void
    ) const
```

Parameters. *None*.

Return value. A `Status` value. For possible values, see Section 2.3.31.4, “Object::Status”.

2.3.37.27 Table::getObjectType()

Description. This method did not work as intended, and was removed in NDB 7.5.0 (Bug #47960, Bug #11756088).

Signature.

```
Object::Type getObjectType
    (
      void
    ) const
```

Parameters. *None*.

Return value. Returns a `Type` value. For possible values, see Section 2.3.31.6, “Object::Type”.

2.3.37.28 Table::getObjectVersion()

Description. This method gets the table's object version (see NDB Schema Object Versions).

Signature.

```
virtual int getObjectVersion
    (
      void
    ) const
```

Parameters. *None*.

Return value. The table's object version, as an integer.

2.3.37.29 Table::getPartitionBalance()

Description. This method gets the table' partition balance scheme (fragment count type).

Signature.

```
Object::PartitionBalance getPartitionBalance
    (
      void
    ) const
```

Parameters. *None*.

Return value. The partition balancing scheme, as a value of type `Object::PartitionBalance`.

Prior to NDB 7.5.4, this method was known as `getFragmentCountType()`.

2.3.37.30 Table::getPartitionBalanceString()

Description. This method gets the table' partition balance scheme (fragment count type), and returns it as a string.

Signature.

```
const char* getPartitionBalanceString
    (
      void
    ) const
```

Parameters. *None*.

Return value. The partition balancing scheme, as a string value.

Prior to NDB 7.5.4, this method was known as `getFragmentCountTypeString()`.

2.3.37.31 Table::getPartitionId()

Description. Gets a table partition ID given its hash value.

Signature.

```
Uint32 getPartitionId
    (
      Uint32 hashvalue
    ) const
```

Parameters. A *`hashvalue`*. Note that if the table has not actually been retrieved (using, for example, `getTableId()`), then the result is likely not to be accurate or useful.

Return value. The identifier of the partition corresponding to the *`hashvalue`*.

2.3.37.32 Table::getPrimaryKey()

Description. This method is used to obtain the name of the table's primary key.

Signature.

```
const char* getPrimaryKey
    (
      int no
    ) const
```

Parameters. *None*.

Return value. The name of the primary key, a string (character pointer).

2.3.37.33 Table::getRangeListData()

Description. This method gets the range or list data associated with the table.

Signature.

```
const void* getRangeListData
    (
      void
    ) const
```

Parameters. *None*.

Return value. A pointer to the data.

2.3.37.34 Table::getRangeListDataLen()

Description. This method gets the size of the table's range or list array.

Signature.

```
Uint32 getRangeListDataLen
    (
      void
    ) const
```

Parameters. *None*.

Return value. The length of the list or range array, as an integer.

2.3.37.35 Table::getRowChecksumIndicator()

Description. Check whether the row checksum indicator has been set.

Signature.

```
bool getRowChecksumIndicator
    (
      void
    ) const
```

Parameters. *None*.

Return value. A `true` or `false` value.

2.3.37.36 Table::getRowGCIIndicator()

Description. Checks whether the row GCI indicator has been set.

Signature.

```
bool getRowGCIIndicator
    (
      void
    ) const
```

Parameters. *None*.

Return value. A `true` or `false` value.

2.3.37.37 Table::getSingleUserMode()

Description. Gets the single user mode of the table.

Signature.

```
enum SingleUserMode getSingleUserMode
    (
      void
    ) const
```

Parameters. *None*.

Return value. A `SingleUserMode` value.

2.3.37.38 Table::getTableId()

Description. This method gets a table's ID.

Signature.

```
int getTableId
    (
      void
    ) const
```

Parameters. *None*.

Return value. An integer.

2.3.37.39 Table::getTablespace()

Description. This method is used in two ways: to obtain the name of the tablespace to which this table is assigned; to verify that a given tablespace is the one being used by this table.

Signatures. To obtain the name of the tablespace, invoke without any arguments:

```
const char* getTablespace
    (
      void
    ) const
```

To determine whether the tablespace is the one indicated by the given ID and version, supply these as arguments, as shown here:

```
bool getTablespace
    (
      Uint32* id      = 0,
```

```
    Uint32* version = 0
    ) const
```

Parameters. The number and types of parameters depend on how this method is being used:

A. When used to obtain the name of the tablespace in use by the table, it is called without any arguments.

B. When used to determine whether the given tablespace is the one being used by this table, then getTablespace() takes two parameters:

   - The tablespace *`id`*, given as a pointer to a 32-bit unsigned integer

   - The tablespace *`version`*, also given as a pointer to a 32-bit unsigned integer

   The default value for both *`id`* and *`version`* is `0`.

Return value. The return type depends on how the method is called.

A. When `getTablespace()` is called without any arguments, it returns a `Tablespace` object instance.

B. When called with two arguments, it returns `true` if the tablespace is the same as the one having the ID and version indicated; otherwise, it returns `false`.

2.3.37.40 Table::getTablespaceData()

Description. This method gets the table's tablespace data (ID and version).

Signature.

```
const void* getTablespaceData
    (
      void
    ) const
```

Parameters. *None*.

Return value. A pointer to the data.

2.3.37.41 Table::getTablespaceDataLen()

Description. This method is used to get the length of the table's tablespace data.

Signature.

```
Uint32 getTablespaceDataLen
    (
      void
    ) const
```

Parameters. *None*.

Return value. The length of the data, as a 32-bit unsigned integer.

2.3.37.42 Table::getTablespaceNames()

Description. This method gets a pointer to the names of the tablespaces used in the table fragments.

Signature.

```
const void* getTablespaceNames
    (
      void
    )
```

Parameters. *None*.

Return value. Returns a pointer to the tablespace name data.

2.3.37.43 Table::getTablespaceNamesLen()

Description. This method gets the length of the tablespace name data returned by `getTablespaceNames()`. (See Section 2.3.37.42, "Table::getTablespaceNames()".)

Signature.

```
Uint32 getTablespaceNamesLen
    (
      void
    ) const
```

Parameters. *None*.

Return value. Returns the length of the name data, in bytes, as a 32-but unsigned integer.

2.3.37.44 Table::hasDefaultValues()

Description. Used to determine whether the table has any columns that are defined with non-`NULL` default values.

To read and write default column values, use `Column::getDefaultValue()` and `Column::setDefaultValue()`.

Signature.

```
bool hasDefaultValues
    (
      void
    ) const
```

Parameters. *None*.

Return value. Returns `true` if the table has any non-`NULL` columns with default values, otherwise `false`.

2.3.37.45 Table::setDefaultNoPartitionsFlag()

Description. This method sets an indicator that determines whether the default number of partitions is used for the table.

Signature.

```
void setDefaultNoPartitionsFlag
    (
      Uint32 indicator
    ) const
```

Parameters. This method takes a single argument *`indicator`*, a 32-bit unsigned integer.

Return value. *None*.

2.3.37.46 Table::setExtraMetadata()

Description. Store packed extra metadata for this table. The data is packed without any modification into the buffer of the given `Table` object.

Signature.

```
int setExtraMetadata
    (
      Uint32 version,
      const void* data,
      Uint32 length
    )
```

Parameters. The three parameters used by this method are listed here:

- *`version`*: As used in NDB Cluster code, `1` means that the extra metadata contains a `.frm` file (`BLOB`) as in NDB 7.6 and earlier; `2` indicates that it is serialized dictionary information as in NDB 8.0. You should be aware that this is merely a convention, and the values can be application-specific, as desired.
- *`data`*: The actual data to be stored as metadata.
- *`length`*: The length of the data to be stored.

Return value. `0` on success. Any other value indicates failure; in this case, the value is an error code indicating indicating the type of error.

Added in NDB 8.0.13.

2.3.37.47 Table::setFragmentCount()

Description. Sets the number of table fragments.

Signature.

```
void setFragmentCount
    (
      Uint32 count
    )
```

Parameters. *`count`* is the number of fragments to be used for the table.

Return value. *None*.

2.3.37.48 Table::setFragmentData()

Description. This method writes an array containing the following fragment information:

- Fragment ID
- Node group ID
- Fragment State

Signature.

```
void setFragmentData
    (
      const void* data,
      Uint32      len
    )
```

Parameters. This method takes the following two parameters:

- A pointer to the fragment *`data`* to be written

- The length (*len*) of this data, in bytes, as a 32-bit unsigned integer

Return value. *None*.

2.3.37.49 Table::setFragmentType()

Description. This method sets the table's fragmentation type.

Signature.

```
void setFragmentType
    (
      FragmentType fragmentType
    )
```

Parameters. This method takes one argument, a `FragmentType` value. See Section 2.3.31.1, “Object::FragmentType”, for more information.

Return value. *None*.

2.3.37.50 Table::setFrm()

Description. This method is used to write data to this table's `.FRM` file.

Signature.

```
void setFrm
    (
      const void* data,
      Uint32      len
    )
```

Parameters. This method takes the following two arguments:

- A pointer to the *data* to be written.
- The length (*len*) of the data.

Return value. *None*.

2.3.37.51 Table::setHashMap()

Description. Set a hash map for the table.

Signature.

```
int setHashMap
    (
      const class HashMap &
    )
```

Parameters. A reference to the hash map.

Return value. Returns 0 on success; on failure, returns -1 and sets error.

2.3.37.52 Table::setKValue()

Description. This sets the `KValue`, a hashing parameter.

Signature.

```
void setKValue
    (
```

```
        int kValue
    )
```

Parameters. *kValue* is an integer. Currently the only permitted value is 6. In a future version this may become a variable parameter.

Return value. *None*.

2.3.37.53 Table::setLinearFlag()

Description.

Signature.

```
void setLinearFlag
    (
      Uint32 flag
    )
```

Parameters. The *flag* is a 32-bit unsigned integer.

Return value. *None*.

2.3.37.54 Table::setLogging()

Description. Toggles the table's logging state. See Section 2.3.37.18, “Table::getLogging()”.

Signature.

```
void setLogging
    (
      bool enable
    )
```

Parameters. If *enable* is true, then logging for this table is enabled; if it is false, then logging is disabled.

Return value. *None*.

2.3.37.55 Table::setMaxLoadFactor()

Description. This method sets the maximum load factor when splitting the containers in the local hash tables.

Signature.

```
void setMaxLoadFactor
    (
      int max
    )
```

Parameters. This method takes a single parameter *max*, an integer representation of a percentage (for example, 45 represents 45 percent). For more information, see Section 2.3.37.19, “Table::getMaxLoadFactor()”.

> **Caution**
>
> This should never be greater than the minimum load factor.

Return value. *None*.

2.3.37.56 Table::setMaxRows()

Description. This method sets the maximum number of rows that can be held by the table.

Signature.

```
void setMaxRows
    (
      Uint64 maxRows
    )
```

Parameters. `maxRows` is a 64-bit unsigned integer that represents the maximum number of rows to be held in the table.

Return value. *None*.

2.3.37.57 Table::setMinLoadFactor()

Description. This method sets the minimum load factor when reduction of the hash table begins.

Signature.

```
void setMinLoadFactor
    (
      int min
    )
```

Parameters. This method takes a single parameter `min`, an integer representation of a percentage (for example, `45` represents 45 percent). For more information, see Section 2.3.37.21, “Table::getMinLoadFactor()”.

Return value. *None*.

2.3.37.58 Table::setName()

Description. This method sets the name of the table.

Note

This is the only `set*()` method of `Table` whose effects are visible to MySQL.

Signature.

```
void setName
    (
      const char* name
    )
```

Parameters. `name` is the (new) name of the table.

Return value. *None*.

2.3.37.59 Table::setObjectType()

Description. This method did not work as intended, and was removed in NDB 7.5.0 (Bug #47960, Bug #11756088).

Signature.

```
void setObjectType
    (
      Object::Type type
    )
```

Parameters. The desired object *`type`*. This must be one of the `Type` values listed in Section 2.3.31.6, “Object::Type”.

Return value. *None*.

2.3.37.60 Table::setPartitionBalance()

Description. Sets the table's partition balancing scheme.

Signature.

```
void setPartitionBalance
    (
      Object::PartitionBalance scheme
    )
```

Parameters. *`scheme`* is the partition balancing scheme to be used for the table. This is a value of type `PartitionBalance`.

Return value. *None*.

Prior to NDB 7.5.4, this method was known as `setFragmentCountType()`.

2.3.37.61 Table::setRangeListData()

Description. This method sets an array containing information that maps range values and list values to fragments. This is essentially a sorted map consisting of fragment-ID/value pairs. For range partitions there is one pair per fragment. For list partitions it could be any number of pairs, but at least as many pairs as there are fragments.

Signature.

```
void setRangeListData
    (
      const void* data,
      Uint32      len
    )
```

Parameters. This method requires the following two parameters:

- A pointer to the range or list *`data`* containing the ID/value pairs
- The length (*`len`*) of this data, as a 32-bit unsigned integer.

Return value. *None*.

2.3.37.62 Table::setRowChecksumIndicator()

Description. *Set the row checksum indicator.*

Signature.

```
void setRowChecksumIndicator
    (
      bool value
    ) const
```

Parameters. A `true`/`false` *`value`*.

Return value. *None*.

2.3.37.63 Table::setRowGCIIndicator()

Description. *Sets the row GCI indicator.*

Signature.

```
void setRowGCIIndicator
    (
      bool value
    ) const
```

Parameters. A `true`/`false` *`value`*.

Return value. *None*.

2.3.37.64 Table::setSingleUserMode()

Description. Sets a `SingleUserMode` for the table.

Signature.

```
void setSingleUserMode
    (
      enum SingleUserMode
    )
```

Parameters. A `SingleUserMode` value.

Return value. *None*.

2.3.37.65 Table::setStatusInvalid()

Description. Forces the table's status to be invalidated.

Signature.

```
void setStatusInvalid
    (
      void
    ) const
```

Parameters. *None*.

Return value. *None*.

2.3.37.66 Table::setTablespace()

Description. This method sets the tablespace for the table.

Signatures. Using the name of the tablespace:

```
void setTablespace
    (
      const char* name
    )
```

Using a `Tablespace` object:

```
void setTablespace
    (
      const class Tablespace& tablespace
    )
```

Parameters. This method can be called with a single argument, which can be of either one of these two types:

1. The *`name`* of the tablespace (a string).

2. A reference to an existing `Tablespace` instance.

See Section 2.3.38, “The Tablespace Class”.

Return value. *None*.

2.3.37.67 Table::setTablespaceData()

Description. This method sets the tablespace information for each fragment, and includes a tablespace ID and a tablespace version.

Signature.

```
void setTablespaceData
    (
      const void* data,
      Uint32      len
    )
```

Parameters. This method requires the following two parameters:

- A pointer to the *`data`* containing the tablespace ID and version

- The length (*`len`*) of this data, as a 32-bit unsigned integer.

Return value. *None*.

2.3.37.68 Table::setTablespaceNames()

Description. Sets the names of the tablespaces used by the table fragments.

Signature.

```
void setTablespaceNames
    (
      const void* data
      Uint32      len
    )
```

Parameters. This method takes the following two parameters:

- A pointer to the tablespace names *`data`*

- The length (*`len`*) of the names data, as a 32-bit unsigned integer.

Return value. *None*.

2.3.37.69 Table::SingleUserMode

Description. Single user mode specifies access rights to the table when single user mode is in effect.

Enumeration values. Possible values for `SingleUserMode` are shown, along with descriptions, in the following table:

Table 2.87 Table::SingleUserMode values and descriptions

Name	Description
`SingleUserModeLocked`	The table is locked (unavailable).
`SingleUserModeReadOnly`	The table is available in read-only mode.

Name	Description
SingleUserModeReadWrite	The table is available in read-write mode.

2.3.37.70 Table::validate()

Description. This method validates the definition for a new table prior to its being created, and executes the `Table::aggregate()` method, as well as performing additional checks. `validate()` is called automatically when a table is created or retrieved. For this reason, it is usually not necessary to call `aggregate()` or `validate()` directly.

Warning

Even after the `validate()` method is called, there may still exist errors which can be detected only by the `NDB` kernel when the table is actually created.

Note

This method was added in MySQL 5.1.12 (see Bug #21690).

Signature.

```
int validate
    (
      struct NdbError& error
    )
```

Parameters. A reference to an `NdbError` object.

Return value. An integer, whose value is `0` on success, and `-1` if the table is in an inconsistent state. In the latter case, the *`error`* is also set.

2.3.38 The Tablespace Class

This section discusses the `Tablespace` class and its public members.

Parent class. `NdbDictionary`

Child classes. *None*

Description. The `Tablespace` class models an NDB Cluster Disk Data tablespace, which contains the datafiles used to store Cluster Disk Data. For an overview of Cluster Disk Data and their characteristics, see CREATE TABLESPACE Statement, in the MySQL Manual.

Note

Currently, only unindexed column data can be stored on disk. Indexes and indexes columns are always stored in memory.

NDB Cluster prior to MySQL 5.1 does not support Disk Data storage, and so does not support tablespaces; thus the `Tablespace` class is unavailable for NDB API applications written against these older releases.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.88 Tablespace class methods and descriptions

Name	Description
Tablespace()	Class constructor

Name	Description
`~Tablespace()`	Virtual destructor method
`getAutoGrowSpecification()`	Used to obtain the `AutoGrowSpecification` structure associated with the tablespace
`getDefaultLogfileGroup()`	Gets the name of the tablespace's default log file group
`getDefaultLogfileGroupId()`	Gets the ID of the tablespace's default log file group
`getExtentSize()`	Gets the extent size used by the tablespace
`getName()`	Gets the name of the tablespace
`getObjectId()`	Gets the object ID of a `Tablespace` instance
`getObjectStatus()`	Used to obtain the `Object::Status` of the `Tablespace` instance for which it is called
`getObjectVersion()`	Gets the object version of the `Tablespace` object for which it is invoked
`setAutoGrowSpecification()`	Used to set the auto-grow characteristics of the tablespace
`setDefaultLogfileGroup()`	Sets the tablespace's default log file group
`setExtentSize()`	Sets the size of the extents used by the tablespace
`setName()`	Sets the name for the tablespace

Types. The Tablespace class defines no public types of its own; however, two of its methods make use of the `AutoGrowSpecification` data structure.

2.3.38.1 Tablespace Constructor

Description. These methods are used to create a new instance of `Tablespace`, or to copy an existing one.

Note

The `Dictionary` class also supplies methods for creating and dropping tablespaces.

Signatures. New instance:

```
Tablespace
    (
      void
    )
```

Copy constructor:

```
Tablespace
    (
      const Tablespace& tablespace
    )
```

Parameters. New instance: *None*. Copy constructor: a reference to an existing `Tablespace` instance.

Return value. A `Tablespace` object.

Destructor. The class defines a virtual destructor `~Tablespace()` which takes no arguments and returns no value.

2.3.38.2 Tablespace::getAutoGrowSpecification()

Description.

Signature.

```
const AutoGrowSpecification& getAutoGrowSpecification
    (
      void
    ) const
```

Parameters. *None*.

Return value. A reference to the structure which describes the tablespace auto-grow characteristics; for details, see Section 2.3.1, "The AutoGrowSpecification Structure".

2.3.38.3 Tablespace::getDefaultLogfileGroup()

Description. This method retrieves the name of the tablespace's default log file group.

> **Note**
>
> Alternatively, you may wish to obtain the ID of the default log file group; see Section 2.3.38.4, "Tablespace::getDefaultLogfileGroupId()".

Signature.

```
const char* getDefaultLogfileGroup
    (
      void
    ) const
```

Parameters. *None*.

Return value. The name of the log file group (string value as character pointer).

2.3.38.4 Tablespace::getDefaultLogfileGroupId()

Description. This method retrieves the ID of the tablespace's default log file group.

> **Note**
>
> You can also obtain directly the name of the default log file group rather than its ID; see Section 2.3.38.3, "Tablespace::getDefaultLogfileGroup()", for more information.

Signature.

```
Uint32 getDefaultLogfileGroupId
    (
      void
    ) const
```

Parameters. *None*.

Return value. The ID of the log file group, as an unsigned 32-bit integer.

2.3.38.5 Tablespace::getExtentSize()

Description. This method is used to retrieve the *extent size*—that is the size of the memory allocation units—used by the tablespace.

> **Note**
>
> The same extent size is used for all datafiles contained in a given tablespace.

Signature.

```
Uint32 getExtentSize
    (
      void
    ) const
```

Parameters. *None*.

Return value. The tablespace's extent size in bytes, as an unsigned 32-bit integer.

2.3.38.6 Tablespace::getObjectId()

Description. This method retrieves the tablespace's object ID.

Signature.

```
virtual int getObjectId
    (
      void
    ) const
```

Parameters. *None*.

Return value. The object ID, as an integer.

2.3.38.7 Tablespace::getName()

Description. This method retrieves the name of the tablespace.

Signature.

```
const char* getName
    (
      void
    ) const
```

Parameters. *None*.

Return value. The name of the tablespace, a string value (as a character pointer).

2.3.38.8 Tablespace::getObjectStatus()

Description. This method is used to retrieve the object status of a tablespace.

Signature.

```
virtual Object::Status getObjectStatus
    (
      void
    ) const
```

Parameters. *None*.

Return value. An `Object::Status` value.

2.3.38.9 Tablespace::getObjectVersion()

Description. This method gets the tablespace object version (see NDB Schema Object Versions).

Signature.

```
virtual int getObjectVersion
```

```
  (
    void
  ) const
```

Parameters. *None*.

Return value. The object version, as an integer.

2.3.38.10 Tablespace::setAutoGrowSpecification()

Description. This method is used to set the auto-grow characteristics of the tablespace.

Signature.

```
void setAutoGrowSpecification
    (
      const AutoGrowSpecification& autoGrowSpec
    )
```

Parameters. This method takes a single parameter, an `AutoGrowSpecification` data structure.

Return value. *None*.

2.3.38.11 Tablespace::setDefaultLogfileGroup()

Description. This method is used to set a tablespace's default log file group.

Signature. This method can be called in two different ways. The first of these uses the name of the log file group, as shown here:

```
void setDefaultLogfileGroup
    (
      const char* name
    )
```

This method can also be called by passing it a reference to a `LogfileGroup` object:

```
void setDefaultLogfileGroup
    (
      const class LogfileGroup& lGroup
    )
```

Note

There is no method for setting a log file group as the default for a tablespace by referencing the log file group's ID. (In other words, there is no `set*()` method corresponding to `getDefaultLogfileGroupId()`.)

Parameters. Either the *`name`* of the log file group to be assigned to the tablespace, or a reference *`lGroup`* to this log file group.

Return value. *None*.

2.3.38.12 Tablespace::setExtentSize()

Description. This method sets the tablespace's extent size.

Signature.

```
void setExtentSize
    (
      Uint32 size
```

```
    )
```

Parameters. The *`size`* to be used for this tablespace's extents, in bytes.

Return value. *None*.

2.3.38.13 Tablespace::setName()

Description. This method sets the name of the tablespace.

Signature.

```
void setName
    (
      const char* name
    ) const
```

Parameters. The *`name`* of the tablespace, a string (character pointer).

Return value. *None*.

2.3.39 The Undofile Class

The section discusses the `Undofile` class and its public methods.

Parent class. `NdbDictionary`

Child classes. *None*

Description. The `Undofile` class models an NDB Cluster Disk Data undofile, which stores data used for rolling back transactions.

Note

Currently, only unindexed column data can be stored on disk. Indexes and indexes columns are always stored in memory.

NDB Cluster prior to MySQL 5.1 does not support Disk Data storage, and so does not support undo files; thus the `Undofile` class is unavailable for NDB API applications written against these older releases.

Methods. The following table lists the public methods of this class and the purpose or use of each method:

Table 2.89 Undofile class methods and descriptions

Name	Description
`Undofile()`	Class constructor
`~Undofile()`	Virtual destructor
`getFileNo()`	Removed in NDB 7.5.0 (Bug #47960, Bug #11756088)
`getLogfileGroup()`	Gets the name of the log file group to which the undo file belongs
`getLogfileGroupId()`	Gets the ID of the log file group to which the undo file belongs
`getNode()`	Removed in NDB 7.5.0 (Bug #47960, Bug #11756088)
`getObjectId()`	Gets the undo file's object ID
`getObjectStatus()`	Gets the undo file's `Status`
`getObjectVersion()`	Gets the undo file's object version

Name	Description
`getPath()`	Gets the undo file's file system path
`getSize()`	Gets the size of the undo file
`setLogfileGroup()`	Sets the undo file's log file group using the name of the log file group or a reference to the corresponding `LogfileGroup` object
`setNode()`	Removed in NDB 7.5.0 (Bug #47960, Bug #11756088)
`setPath()`	Sets the file system path for the undo file
`setSize()`	Sets the undo file's size

Types. The `Undofile` class defines no public types.

2.3.39.1 Undofile Constructor

Description. The class constructor can be used to create a new `Undofile` instance, or to copy an existing one.

Signatures. Creates a new instance:

```
Undofile
    (
      void
    )
```

Copy constructor:

```
Undofile
    (
      const Undofile& undoFile
    )
```

Parameters. New instance: *None*. The copy constructor takes a single argument—a reference to the `Undofile` object to be copied.

Return value. An `Undofile` object.

Destructor. The class defines a virtual destructor which takes no arguments and has the return type `void`.

2.3.39.2 Undofile::getFileNo()

Description. This method did not work as intended, and was removed in NDB 7.5.0 (Bug #47960, Bug #11756088).

Signature.

```
Uint32 getFileNo
    (
      void
    ) const
```

Parameters. *None*.

Return value. The number of the undo file, as an unsigned 32-bit integer.

2.3.39.3 Undofile::getLogfileGroup()

Description. This method retrieves the name of the log file group to which the undo file belongs.

Signature.

```
const char* getLogfileGroup
    (
      void
    ) const
```

Parameters. *None*.

Return value. The name of the log file group, a string value (as a character pointer).

2.3.39.4 Undofile::getLogfileGroupId()

Description. This method retrieves the ID of the log file group to which the undo file belongs.

> **Note**
>
> It is also possible to obtain the name of the log file group directly. See Section 2.3.39.3, "Undofile::getLogfileGroup()"

Signature.

```
Uint32 getLogfileGroupId
    (
      void
    ) const
```

Parameters. *None*.

Return value. The ID of the log file group, as an unsigned 32-bit integer.

2.3.39.5 Undofile::getNode()

Description. This method did not work as intended, and was removed in NDB 7.5.0 (Bug #47960, Bug #11756088).

Signature.

```
Uint32 getNode
    (
      void
    ) const
```

Parameters. *None*.

Return value. The node ID, as an unsigned 32-bit integer.

2.3.39.6 Undofile::getObjectId()

Description. This method retrieves the undo file's object ID.

Signature.

```
virtual int getObjectId
    (
      void
    ) const
```

Parameters. *None*.

Return value. The object ID, as an integer.

2.3.39.7 Undofile::getObjectStatus()

Description. This method is used to retrieve the object status of an undo file.

Signature.

```
virtual Object::Status getObjectStatus
    (
      void
    ) const
```

Parameters. *None*.

Return value. An `Object::Status` value.

2.3.39.8 Undofile::getObjectVersion()

Description. This method gets the undo file's object version (see NDB Schema Object Versions).

Signature.

```
virtual int getObjectVersion
  (
    void
  ) const
```

Parameters. *None*.

Return value. The object version, as an integer.

2.3.39.9 Undofile::getPath()

Description. This method retrieves the path matching the location of the undo file on the data node's file system.

Signature.

```
const char* getPath
    (
      void
    ) const
```

Parameters. *None*.

Return value. The file system path, a string (as a character pointer).

2.3.39.10 Undofile::getSize()

Description. This method gets the size of the undo file in bytes.

Signature.

```
Uint64 getSize
    (
      void
    ) const
```

Parameters. *None*.

Return value. The size in bytes of the undo file, as an unsigned 64-bit integer.

2.3.39.11 Undofile::setLogfileGroup()

Description. Given either a name or an object reference to a log file group, the `setLogfileGroup()` method assigns the undo file to that log file group.

Signature. Using a log file group name:

```
void setLogfileGroup
    (
      const char* name
    )
```

Using a reference to an instance of `LogfileGroup`:

```
void setLogfileGroup
    (
      const class LogfileGroup & logfileGroup
    )
```

Parameters. The *`name`* of the log file group (a character pointer), or a reference to a `LogfileGroup` instance.

Return value. *None*.

2.3.39.12 Undofile::setNode()

Description. This method did not work as intended, and was removed in NDB 7.5.0 (Bug #47960, Bug #11756088).

Signature.

```
void setNode
    (
      Uint32 nodeId
    )
```

Parameters. The *`nodeId`* of the data node where the undo file is to be placed; this is an unsigned 32-bit integer.

Return value. *None*.

2.3.39.13 Undofile::setPath()

Description. This method is used to set the file system path of the undo file on the data node where it resides.

Signature.

```
void setPath
    (
      const char* path
    )
```

Parameters. The desired *`path`* to the undo file.

Return value. *None*.

2.3.39.14 Undofile::setSize()

Description. Sets the size of the undo file in bytes.

Signature.

```
void setSize
    (
```

```
    Uint64 size
  )
```

Parameters. The intended *size* of the undo file in bytes, as an unsigned 64-bit integer.

Return value. *None*.

2.4 NDB API Errors and Error Handling

This section contains a discussion of error handling in NDB API applications as well as listing listings of the most common `NDB` error codes and messages, along with their classifications and likely causes for which they might be raised.

For information about the `NdbError` structure, which is used to convey error information to NDB API applications, see Section 2.3.20, “The NdbError Structure”.

Important

It is strongly recommended that you *not* depend on specific error codes in your `NDB` API applications, as they are subject to change over time. Instead, you should use the `NdbError::Status` and error classification in your source code, or consult the output of `perror --ndb error_code` to obtain information about a specific error code.

If you find a situation in which you need to use a specific error code in your application, please file a bug report at http://bugs.mysql.com/ so that we can update the corresponding status and classification.

2.4.1 Handling NDB API Errors

This section describes how NDB API errors can be detected and mapped onto particular operations.

NDB API errors can be generated in either of two ways:

- When an operation is defined
- When an operation is executed

Errors raised during operation definition. Errors generated during operation definition result in a failure return code from the method called. The actual error can be determined by examining the relevant `NdbOperation` object, or the operation's `NdbTransaction` object.

Errors raised during operation execution. Errors occurring during operation execution cause the transaction of which they are a part to be aborted unless the `AO_IgnoreError` abort option is set for the operation.

By default, read operations are run with `AO_IgnoreError`, and write operations are run with `AbortOnError`, but this can be overridden by the user. When an error during execution causes a transaction to be aborted, the `execute()` method returns a failure return code. If an error is ignored due to `AO_IgnoreError` being set on the operation, the `execute()` method returns a success code, and the user must examine all operations for failure using `NdbOperation::getNdbError()`. For this reason, the return value of `getNdbError()` should usually be checked, even if `execute()` returns success. If the client application does not keep track of `NdbOperation` objects during execution, then `NdbTransaction::getNextCompletedOperation()` can be used to iterate over them.

You should also be aware that use of `NdbBlob` can result in extra operations being added to the batches executed. This means that, when iterating over completed operations using `getNextCompletedOperation()`, you may encounter operations related to `NdbBlob` objects which were not defined by your application.

Note

A read whose `LockMode` is `CommittedRead` cannot be `AbortOnError`. In this case, it is always be `IgnoreError`.

In all cases where operation-specific errors arise, an execution error with an operation is marked against both the operation and the associated transaction object. Where there are multiple operation errors in a single `NdbTransaction::execute()` call, due to operation batching and the use of `AO_IgnoreError`, only the first is marked against the `NdbTransaction` object. The remaining errors are recorded against the corresponding `NdbOperation` objects only.

It is also possible for errors to occur during execution—such as a data node failure—which are marked against the transaction object, but *not* against the underlying operation objects. This is because these errors apply to the transaction as a whole, and not to individual operations within the transaction.

For this reason, applications should use `NdbTransaction::getNdbError()` as the first way to determine whether an `NdbTransaction::execute()` call failed. If the batch of operations being executed included operations with the `AO_IgnoreError` abort option set, then it is possible that there were multiple failures, and the completed operations should be checked individually for errors using `NdbOperation::getNdbError()`.

Implicit NdbTransaction::execute() calls in scan and BLOB methods. Scan operations are executed in the same way as other operations, and also have implicit `execute()` calls within the `NdbScanOperation::nextResult()` method. When `NdbScanOperation::nextResult()` indicates failure (that is, if the method returns `-1`), the transaction object should be checked for an error. The `NdbScanOperation` may also contain the error, but only if the error is not operation-specific.

Some `BLOB` manipulation methods also have implicit internal `execute()` calls, and so can experience operation execution failures at these points. The following `NdbBlob` methods can generate implicit `execute()` calls; this means that they also require checks of the `NdbTransaction` object for errors via `NdbTransaction::getNdbError()` if they return an error code:

- `setNull()`
- `truncate()`
- `readData()`
- `writeData()`

Summary. In general, it is possible for an error to occur during execution (resulting in a failure return code) when calling any of the following methods:

- `NdbTransaction::execute()`
- `NdbBlob::setNull()`
- `NdbBlob::truncate()`
- `NdbBlob::readData()`
- `NdbBlob::writeData()`
- `NdbScanOperation::nextResult()`

Note

This method does *not* perform an implicit `execute()` call. The `NdbBlob` methods can cause other defined operations to be executed when these methods are called; however, `nextResult()` calls do not do so.

If this happens, the `NdbTransaction::getNdbError()` method should be called to identify the first error that occurred. When operations are batched, and there are `IgnoreError` operations in the batch, there may be multiple operations with errors in the transaction. These can be found by using `NdbTransaction::getNextCompletedOperation()` to iterate over the set of completed operations, calling `NdbOperation::getNdbError()` for each operation.

When `IgnoreError` has been set on any operations in a batch of operations to be executed, the `NdbTransaction::execute()` method indicates success even where errors have actually occurred, as long as none of these errors caused a transaction to be aborted. To determine whether there were any ignored errors, the transaction error status should be checked using `NdbTransaction::getNdbError()`. *Only if this indicates success can you be certain that no errors occurred*. If an error code is returned by this method, and operations were batched, then you should iterate over all completed operations to find all the operations with ignored errors.

Example (*pseudocode*). We begin by executing a transaction which may have batched operations and a mix of `AO_IgnoreError` and `AbortOnError` abort options:

```
int execResult= NdbTransaction.execute(args);
```

Note

For the number and permitted values of *`args`*, see Section 2.3.30.6, “NdbTransaction::execute()”.

Next, because errors on `AO_IgnoreError` operations do not affect execResult—that is, the value returned by `execute()`—we check for errors on the transaction:

```
NdbError err= NdbTransaction.getNdbError();

if (err.code != 0)
{
```

An nonzero value for the error code means that an error was raised on the transaction. This could be due to any of the following conditions:

- A transaction-wide error, such as a data node failure, that caused the transaction to be aborted
- A single operation-specific error, such as a constraint violation, that caused the transaction to be aborted
- A single operation-specific ignored error, such as no data found, that did not cause the transaction to be aborted
- The first of many operation-specific ignored errors, such as no data found when batching, that did not cause the transaction to be aborted
- First of a number of operation-specific ignored errors such as no data found (when batching) before an aborting operation error (transaction aborted)

```
   if (execResult != 0)
   {
```

The transaction has been aborted. The recommended strategy for handling the error in this case is to test the transaction error status and take appropriate action based on its value:

```
      switch (err.status)
      {
        case value1:
          //  statement block handling value1 ...
        case value2:
          //  statement block handling value2 ...
```

```
          //  (etc. ...)
        case valueN:
          //  statement block handling valueN ...
      }
```

Since the transaction was aborted, it is generally necessary to iterate over the completed operations (if any) and find the errors raised by each only if you wish to do so for reporting purposes.

```
   }
   else
   {
```

The transaction itself was not aborted, but there must be one or more ignored errors. In this case, you should iterate over the operations to determine what happened and handle the cause accordingly.

```
   }
}
```

To handle a `NdbScanOperation::nextResult()` which returns `-1`, indicating that the operation failed (omitting cases where the operation was successful):

```
int nextrc= NdbScanOperation.nextResult(args);
```

Note

For the number and permitted values of *`args`*, see Section 2.3.29.6, “NdbScanOperation::nextResult()”.

```
if (nextrc == -1)
{
```

First, you should check the `NdbScanOperation` object for any errors:

```
  NdbError err= NdbScanOperation.getNdbError();

  if (err.code == 0)
  {
```

No error was found in the scan operation; the error must belong to the transaction as whole.

```
  }
    err= NdbTransaction.getNdbError();
```

Now you can handle the error based on the error status:

```
    switch (err.status)
    {
      case value1:
        //  statement block handling value1 ...
      case value2:
        //  statement block handling value2 ...
        //  (etc. ...)
      case valueN:
        //  statement block handling valueN ...
    }
}
```

For information about NDB API error classification and status codes, see Section 2.4.4, “NDB Error Classifications”. While you should not rely on a specific error code or message text in your NDB API applications—since error codes and messages are both subject to change over time—it can be useful to check error codes and messages to help determine why a particular failure occurred. For more information about these, see Section 2.4.2, “NDB Error Codes: by Type”. For more about `NdbError` and the types of information which can be obtained from `NdbError` objects, see Section 2.3.20, "The NdbError Structure".

2.4.2 NDB Error Codes: by Type

This section contains a number of error code lists, one for each type of NDB API error. The error types include the following:

- No error
- Application error
- Scan application error
- Configuration or application error (currently unused)
- No data found
- Constraint violation
- Schema error
- User defined error
- Insufficient space
- Temporary Resource error
- Node Recovery error
- Overload error
- Timeout expired
- Node shutdown
- Internal temporary
- Unknown result error
- Unknown error code (currently unused)
- Internal error
- Function not implemented

The information in each list includes, for each error:

- The NDB error code
- The corresponding MySQL error code
- The NDB classification code

  See Section 2.4.4, "NDB Error Classifications", for the meanings of these classification codes.
- The text of the error message

Similar errors have been grouped together in each list. Each list is ordered alphabetically.

You can always obtain the latest error codes and information from the file `storage/ndb/src/ndbapi/ndberror.cpp`. (In previous releases of NDB Cluster, this file was named `ndberror.c`.)

These types are also shown in the `error_status` column of the `ndbinfo.error_messages` table.

2.4.2.1 No error

The following list enumerates all `NDB` errors of type `NE` (**`No error`**).

0 **MySQL error.** 0

Error message. No error

2.4.2.2 Application error

The following list enumerates all `NDB` errors of type `AE` (**`Application error`**).

1233 **MySQL error.** DMEC

Error message. Table read-only

1302 **MySQL error.** DMEC

Error message. A backup is already running

1306 **MySQL error.** DMEC

Error message. Backup not supported in diskless mode (change Diskless)

1329 **MySQL error.** DMEC

Error message. Backup during software upgrade not supported

1342 **MySQL error.** DMEC

Error message. Backup failed to allocate buffers (check configuration)

1343 **MySQL error.** DMEC

Error message. Backup failed to setup fs buffers (check configuration)

1344 **MySQL error.** DMEC

Error message. Backup failed to allocate tables (check configuration)

1345 **MySQL error.** DMEC

Error message. Backup failed to insert file header (check configuration)

1346 **MySQL error.** DMEC

Error message. Backup failed to insert table list (check configuration)

1347 **MySQL error.** DMEC

Error message. Backup failed to allocate table memory (check configuration)

1348 **MySQL error.** DMEC

Error message. Backup failed to allocate file record (check configuration)

1349	**MySQL error.** DMEC **Error message.** Backup failed to allocate attribute record (check configuration)
1701	**MySQL error.** DMEC **Error message.** Node already reserved
1702	**MySQL error.** DMEC **Error message.** Node already connected
1704	**MySQL error.** DMEC **Error message.** Node type mismatch
21000	**MySQL error.** HA_ERR_CANNOT_ADD_FOREIGN **Error message.** Create foreign key failed - parent key is primary key and on-update-cascade is not allowed
21026	**MySQL error.** HA_ERR_CANNOT_ADD_FOREIGN **Error message.** Create foreign key failed in NDB - parent index is not unique index
21033	**MySQL error.** HA_ERR_CANNOT_ADD_FOREIGN **Error message.** Create foreign key failed in NDB - No parent row found
21034	**MySQL error.** HA_ERR_CANNOT_ADD_FOREIGN **Error message.** Create foreign key failed - child table has Blob or Text column and on-delete-cascade is not allowed
21040	**MySQL error.** DMEC **Error message.** Drop foreign key failed in NDB - foreign key not found
21060	**MySQL error.** DMEC **Error message.** Build foreign key failed in NDB - foreign key not found
21080	**MySQL error.** HA_ERR_ROW_IS_REFERENCED **Error message.** Drop table not allowed in NDB - referenced by foreign key on another table
21081	**MySQL error.** HA_ERR_DROP_INDEX_FK **Error message.** Drop index not allowed in NDB - used as parent index of a foreign key
21082	**MySQL error.** HA_ERR_DROP_INDEX_FK **Error message.** Drop index not allowed in NDB - used as child index of a foreign key
21090	**MySQL error.** HA_ERR_CANNOT_ADD_FOREIGN

Error message. Create foreign key failed in NDB - name contains invalid character (/)

242 **MySQL error.** DMEC

Error message. Zero concurrency in scan

244 **MySQL error.** DMEC

Error message. Too high concurrency in scan

261 **MySQL error.** DMEC

Error message. DML count in transaction exceeds config parameter MaxDMLOperationsPerTransaction/ MaxNoOfConcurrentOperations

269 **MySQL error.** DMEC

Error message. No condition and attributes to read in scan

281 **MySQL error.** HA_ERR_NO_CONNECTION

Error message. Operation not allowed due to cluster shutdown in progress

299 **MySQL error.** DMEC

Error message. Operation not allowed or aborted due to single user mode

311 **MySQL error.** DMEC

Error message. Undefined partition used in setPartitionId

320 **MySQL error.** DMEC

Error message. Invalid no of nodes specified for new nodegroup

321 **MySQL error.** DMEC

Error message. Invalid nodegroup id

322 **MySQL error.** DMEC

Error message. Invalid node(s) specified for new nodegroup, node already in nodegroup

323 **MySQL error.** DMEC

Error message. Invalid nodegroup id, nodegroup already existing

324 **MySQL error.** DMEC

Error message. Invalid node(s) specified for new nodegroup, no node in nodegroup is started

325 **MySQL error.** DMEC

Error message. Invalid node(s) specified for new nodegroup, node ID invalid or undefined

4004 **MySQL error.** DMEC

Error message. Attribute name or id not found in the table

4100 **MySQL error.** DMEC

Error message. Status Error in NDB

4101 **MySQL error.** DMEC

Error message. No connections to NDB available and connect failed

4102 **MySQL error.** DMEC

Error message. Type in NdbTamper not correct

4103 **MySQL error.** DMEC

Error message. No schema connections to NDB available and connect failed

4104 **MySQL error.** DMEC

Error message. Ndb Init in wrong state, destroy Ndb object and create a new

4105 **MySQL error.** DMEC

Error message. Too many Ndb objects

4106 **MySQL error.** DMEC

Error message. All Not NULL attribute have not been defined

4114 **MySQL error.** DMEC

Error message. Transaction is already completed

4116 **MySQL error.** DMEC

Error message. Operation was not defined correctly, probably missing a key

4117 **MySQL error.** DMEC

Error message. Could not start transporter, configuration error

4118 **MySQL error.** DMEC

Error message. Parameter error in API call

4120 **MySQL error.** DMEC

Error message. Scan already complete

4121 **MySQL error.** DMEC

Error message. Cannot set name twice for an Ndb object

4122 **MySQL error.** DMEC

Error message. Cannot set name after Ndb object is initialised

4123 **MySQL error.** DMEC

Error message. Free percent out of range. Allowed range is 1-99

417 **MySQL error.** DMEC

Error message. Bad operation reference - double unlock

4200 **MySQL error.** DMEC

Error message. Status Error when defining an operation

4201 **MySQL error.** DMEC

Error message. Variable Arrays not yet supported

4202 **MySQL error.** DMEC

Error message. Set value on tuple key attribute is not allowed

4203 **MySQL error.** DMEC

Error message. Trying to set a NOT NULL attribute to NULL

4204 **MySQL error.** DMEC

Error message. Set value and Read/Delete Tuple is incompatible

4205 **MySQL error.** DMEC

Error message. No Key attribute used to define tuple

4206 **MySQL error.** DMEC

Error message. Not allowed to equal key attribute twice

4207 **MySQL error.** DMEC

Error message. Key size is limited to 4092 bytes

4208 **MySQL error.** DMEC

Error message. Trying to read a non-stored attribute

4209 **MySQL error.** DMEC

Error message. Length parameter in equal/setValue is incorrect

4210 **MySQL error.** DMEC

Error message. Ndb sent more info than the length he specified

4211 **MySQL error.** DMEC

Error message. Inconsistency in list of NdbRecAttr-objects

4212 **MySQL error.** DMEC

Error message. Ndb reports NULL value on Not NULL attribute

4213 **MySQL error.** DMEC

Error message. Not all data of an attribute has been received

4214 **MySQL error.** DMEC

Error message. Not all attributes have been received

4215 **MySQL error.** DMEC

Error message. More data received than reported in TCKEYCONF message

4216 **MySQL error.** DMEC

Error message. More than 8052 bytes in setValue cannot be handled

4217 **MySQL error.** DMEC

Error message. It is not allowed to increment any other than unsigned ints

4218 **MySQL error.** DMEC

Error message. Currently not allowed to increment NULL-able attributes

4219 **MySQL error.** DMEC

Error message. Maximum size of interpretative attributes are 64 bits

4220 **MySQL error.** DMEC

Error message. Maximum size of interpretative attributes are 64 bits

4221 **MySQL error.** DMEC

Error message. Trying to jump to a non-defined label

4222 **MySQL error.** DMEC

Error message. Label was not found, internal error

4223 **MySQL error.** DMEC

Error message. Not allowed to create jumps to yourself

4224 **MySQL error.** DMEC

Error message. Not allowed to jump to a label in a different subroutine

4225 **MySQL error.** DMEC

Error message. All primary keys defined, call setValue/getValue

4226 **MySQL error.** DMEC

Error message. Bad number when defining a label

4227 **MySQL error.** DMEC

Error message. Bad number when defining a subroutine

4228 **MySQL error.** DMEC

Error message. Illegal interpreter function in scan definition

4229 **MySQL error.** DMEC

Error message. Illegal register in interpreter function definition

4230 **MySQL error.** DMEC

Error message. Illegal state when calling getValue, probably not a read

4231 **MySQL error.** DMEC

Error message. Illegal state when calling interpreter routine

4232 **MySQL error.** DMEC

Error message. Parallelism can only be between 1 and 240

4233 **MySQL error.** DMEC

Error message. Calling execute (synchronous) when already prepared asynchronous transaction exists

4234 **MySQL error.** DMEC

Error message. Illegal to call setValue in this state

4235 **MySQL error.** DMEC

Error message. No callback from execute

4236 **MySQL error.** DMEC

Error message. Trigger name too long

4237 **MySQL error.** DMEC

Error message. Too many triggers

4238 **MySQL error.** DMEC

Error message. Trigger not found

4239 **MySQL error.** DMEC

Error message. Trigger with given name already exists

4240 **MySQL error.** DMEC

Error message. Unsupported trigger type

4241 **MySQL error.** DMEC

Error message. Index name too long

4242 **MySQL error.** DMEC

Error message. Too many indexes

4243 **MySQL error.** DMEC

Error message. Index not found

4247 **MySQL error.** DMEC

Error message. Illegal index/trigger create/drop/alter request

4248 **MySQL error.** DMEC

Error message. Trigger/index name invalid

4249 **MySQL error.** DMEC

Error message. Invalid table

4250 **MySQL error.** DMEC

Error message. Invalid index type or index logging option

4251 **MySQL error.** HA_ERR_FOUND_DUPP_UNIQUE

Error message. Cannot create unique index, duplicate keys found

4252 **MySQL error.** DMEC

Error message. Failed to allocate space for index

4253 **MySQL error.** DMEC

Error message. Failed to create index table

4254 **MySQL error.** DMEC

Error message. Table not an index table

4255 **MySQL error.** DMEC

Error message. Hash index attributes must be specified in same order as table attributes

4256 **MySQL error.** DMEC

Error message. Must call Ndb::init() before this function

4257 **MySQL error.** DMEC

Error message. Tried to read too much - too many getValue calls

4258 **MySQL error.** DMEC

Error message. Cannot create unique index, duplicate attributes found in definition

4259 **MySQL error.** DMEC

Error message. Invalid set of range scan bounds

4264 **MySQL error.** DMEC

Error message. Invalid usage of blob attribute

4265 **MySQL error.** DMEC

Error message. The method is not valid in current blob state

4266 **MySQL error.** DMEC

Error message. Invalid blob seek position

4271 **MySQL error.** DMEC

Error message. Invalid index object, not retrieved via getIndex()

4272 **MySQL error.** DMEC

Error message. Table definition has undefined column

4275 **MySQL error.** DMEC

Error message. The blob method is incompatible with operation type or lock mode

4276 **MySQL error.** DMEC

Error message. Missing NULL ptr in end of keyData list

4277 **MySQL error.** DMEC

Error message. Key part len is to small for column

4278 **MySQL error.** DMEC

Error message. Supplied buffer to small

4279 **MySQL error.** DMEC

Error message. Malformed string

4280 **MySQL error.** DMEC

Error message. Inconsistent key part length

4281 **MySQL error.** DMEC

Error message. Too many keys specified for key bound in scanIndex

4282 **MySQL error.** DMEC

Error message. range_no not strictly increasing in ordered multi-range index scan

4283 **MySQL error.** DMEC

Error message. key_record in index scan is not an index ndbrecord

4284 **MySQL error.** DMEC

Error message. Cannot mix NdbRecAttr and NdbRecord methods in one operation

4285 **MySQL error.** DMEC

Error message. NULL NdbRecord pointer

4286 **MySQL error.** DMEC

Error message. Invalid range_no (must be < 4096)

4287 **MySQL error.** DMEC

Error message. The key_record and attribute_record in primary key operation do not belong to the same table

4288 **MySQL error.** DMEC

Error message. Blob handle for column not available

4289 **MySQL error.** DMEC

Error message. API version mismatch or wrong sizeof(NdbDictionary::RecordSpecification)

4290 **MySQL error.** DMEC

Error message. Missing column specification in NdbDictionary::RecordSpecification

4291 **MySQL error.** DMEC

Error message. Duplicate column specification in NdbDictionary::RecordSpecification

4292 **MySQL error.** DMEC

Error message. NdbRecord for tuple access is not an index key NdbRecord

4293 **MySQL error.** DMEC

Error message. Error returned from application scanIndex() callback

4294 **MySQL error.** DMEC

Error message. Scan filter is too large, discarded

4295 **MySQL error.** DMEC

Error message. Column is NULL in Get/SetValueSpec structure

4296 **MySQL error.** DMEC

Error message. Invalid AbortOption

4297 **MySQL error.** DMEC

Error message. Invalid or unsupported OperationOptions structure

4298 **MySQL error.** DMEC

Error message. Invalid or unsupported ScanOptions structure

4299 **MySQL error.** DMEC

Error message. Incorrect combination of ScanOption flags, extraGetValues ptr and numExtraGetValues

4300 **MySQL error.** DMEC

Error message. Tuple Key Type not correct

4301 **MySQL error.** DMEC

Error message. Fragment Type not correct

4302 **MySQL error.** DMEC

Error message. Minimum Load Factor not correct

4303 **MySQL error.** DMEC

Error message. Maximum Load Factor not correct

4304 **MySQL error.** DMEC

Error message. Maximum Load Factor smaller than Minimum

4305 **MySQL error.** DMEC

Error message. K value must currently be set to 6

4306 **MySQL error.** DMEC

Error message. Memory Type not correct

4307 **MySQL error.** DMEC

Error message. Invalid table name

4308 **MySQL error.** DMEC

Error message. Attribute Size not correct

4309 **MySQL error.** DMEC

Error message. Fixed array too large, maximum 64000 bytes

4310 **MySQL error.** DMEC

Error message. Attribute Type not correct

4311 **MySQL error.** DMEC

Error message. Storage Mode not correct

4312 **MySQL error.** DMEC

Error message. Null Attribute Type not correct

4313 **MySQL error.** DMEC

Error message. Index only storage for non-key attribute

4314 **MySQL error.** DMEC

Error message. Storage Type of attribute not correct

4315 **MySQL error.** DMEC

Error message. No more key attributes allowed after defining variable length key attribute

4316 **MySQL error.** DMEC

Error message. Key attributes are not allowed to be NULL attributes

4317 **MySQL error.** DMEC

	Error message. Too many primary keys defined in table
4318	**MySQL error.** DMEC
	Error message. Invalid attribute name or number
4319	**MySQL error.** DMEC
	Error message. createAttribute called at erroneus place
4322	**MySQL error.** DMEC
	Error message. Attempt to define distribution key when not prepared to
4323	**MySQL error.** DMEC
	Error message. Distribution Key set on table but not defined on first attribute
4324	**MySQL error.** DMEC
	Error message. Attempt to define distribution group when not prepared to
4325	**MySQL error.** DMEC
	Error message. Distribution Group set on table but not defined on first attribute
4326	**MySQL error.** DMEC
	Error message. Distribution Group with erroneus number of bits
4327	**MySQL error.** DMEC
	Error message. Distribution key is only supported on part of primary key
4328	**MySQL error.** DMEC
	Error message. Disk memory attributes not yet supported
4329	**MySQL error.** DMEC
	Error message. Variable stored attributes not yet supported
4335	**MySQL error.** DMEC
	Error message. Only one autoincrement column allowed per table. Having a table without primary key uses an autoincremented hidden key, i.e. a table without a primary key can not have an autoincremented column
4340	**MySQL error.** DMEC
	Error message. Result or attribute record must be a base table ndbrecord, not an index ndbrecord
4341	**MySQL error.** DMEC
	Error message. Not all keys read when using option SF_OrderBy

4342 **MySQL error.** DMEC

Error message. Scan defined but not prepared

4343 **MySQL error.** DMEC

Error message. Table with blobs does not support refresh

4400 **MySQL error.** DMEC

Error message. Status Error in NdbSchemaCon

4401 **MySQL error.** DMEC

Error message. Only one schema operation per schema transaction

4402 **MySQL error.** DMEC

Error message. No schema operation defined before calling execute

4410 **MySQL error.** DMEC

Error message. Schema transaction is already started

4411 **MySQL error.** DMEC

Error message. Schema transaction not possible until upgrade complete

4412 **MySQL error.** DMEC

Error message. Schema transaction is not started

4501 **MySQL error.** DMEC

Error message. Insert in hash table failed when getting table information from Ndb

4502 **MySQL error.** DMEC

Error message. GetValue not allowed in Update operation

4503 **MySQL error.** DMEC

Error message. GetValue not allowed in Insert operation

4504 **MySQL error.** DMEC

Error message. SetValue not allowed in Read operation

4505 **MySQL error.** DMEC

Error message. NULL value not allowed in primary key search

4506 **MySQL error.** DMEC

Error message. Missing getValue/setValue when calling execute

4507 **MySQL error.** DMEC

Error message. Missing operation request when calling execute

4508 **MySQL error.** DMEC

Error message. GetValue not allowed for NdbRecord defined operation

4509 **MySQL error.** DMEC

Error message. Non SF_MultiRange scan cannot have more than one bound

4510 **MySQL error.** DMEC

Error message. User specified partition id not allowed for scan takeover operation

4511 **MySQL error.** DMEC

Error message. Blobs not allowed in NdbRecord delete result record

4512 **MySQL error.** DMEC

Error message. Incorrect combination of OperationOptions optionsPresent, extraGet/SetValues ptr and numExtraGet/SetValues

4513 **MySQL error.** DMEC

Error message. Only one scan bound allowed for non-NdbRecord setBound() API

4514 **MySQL error.** DMEC

Error message. Can only call setBound/equal() for an NdbIndexScanOperation

4515 **MySQL error.** DMEC

Error message. Method not allowed for NdbRecord, use OperationOptions or ScanOptions structure instead

4516 **MySQL error.** DMEC

Error message. Illegal instruction in interpreted program

4517 **MySQL error.** DMEC

Error message. Bad label in branch instruction

4518 **MySQL error.** DMEC

Error message. Too many instructions in interpreted program

4519 **MySQL error.** DMEC

Error message. NdbInterpretedCode::finalise() not called

4520 **MySQL error.** DMEC

Error message. Call to undefined subroutine

4521 **MySQL error.** DMEC

Error message. Call to undefined subroutine, internal error

4522 **MySQL error.** DMEC

Error message. setBound() called twice for same key

4523 **MySQL error.** DMEC

Error message. Pseudo columns not supported by NdbRecord

4524 **MySQL error.** DMEC

Error message. NdbInterpretedCode is for different table

4535 **MySQL error.** DMEC

Error message. Attempt to set bound on non key column

4536 **MySQL error.** DMEC

Error message. NdbScanFilter constructor taking NdbOperation is not supported for NdbRecord

4537 **MySQL error.** DMEC

Error message. Wrong API. Use NdbInterpretedCode for NdbRecord operations

4538 **MySQL error.** DMEC

Error message. NdbInterpretedCode instruction requires that table is set

4539 **MySQL error.** DMEC

Error message. NdbInterpretedCode not supported for operation type

4540 **MySQL error.** DMEC

Error message. Attempt to pass an Index column to createRecord. Use base table columns only

4542 **MySQL error.** DMEC

Error message. Unknown partition information type

4543 **MySQL error.** DMEC

Error message. Duplicate partitioning information supplied

4544 **MySQL error.** DMEC

Error message. Wrong partitionInfo type for table

4545 **MySQL error.** DMEC

Error message. Invalid or Unsupported PartitionInfo structure

4546 **MySQL error.** DMEC

Error message. Explicit partitioning info not allowed for table and operation

4547 **MySQL error.** DMEC

	Error message. RecordSpecification has overlapping offsets
4548	**MySQL error.** DMEC
	Error message. RecordSpecification has too many elements
4549	**MySQL error.** DMEC
	Error message. getLockHandle only supported for primary key read with a lock
4550	**MySQL error.** DMEC
	Error message. Cannot releaseLockHandle until operation executed
4551	**MySQL error.** DMEC
	Error message. NdbLockHandle already released
4552	**MySQL error.** DMEC
	Error message. NdbLockHandle does not belong to transaction
4553	**MySQL error.** DMEC
	Error message. NdbLockHandle original operation not executed successfully
4554	**MySQL error.** DMEC
	Error message. NdbBlob can only be closed from Active state
4555	**MySQL error.** DMEC
	Error message. NdbBlob cannot be closed with pending operations
4556	**MySQL error.** DMEC
	Error message. RecordSpecification has illegal value in column_flags
4557	**MySQL error.** DMEC
	Error message. Column types must be identical when comparing two columns
4600	**MySQL error.** DMEC
	Error message. Transaction is already started
4601	**MySQL error.** DMEC
	Error message. Transaction is not started
4602	**MySQL error.** DMEC
	Error message. You must call getNdbOperation before executeScan
4603	**MySQL error.** DMEC

	Error message. There can only be ONE operation in a scan transaction
4604	**MySQL error.** DMEC
	Error message. takeOverScanOp, to take over a scanned row one must explicitly request keyinfo on readTuples call
4605	**MySQL error.** DMEC
	Error message. You may only call readTuples() once for each operation
4607	**MySQL error.** DMEC
	Error message. There may only be one operation in a scan transaction
4608	**MySQL error.** DMEC
	Error message. You can not takeOverScan unless you have used openScanExclusive
4609	**MySQL error.** DMEC
	Error message. You must call nextScanResult before trying to takeOverScan
4707	**MySQL error.** DMEC
	Error message. Too many event have been defined
4708	**MySQL error.** DMEC
	Error message. Event name is too long
4709	**MySQL error.** DMEC
	Error message. Can't accept more subscribers
4710	**MySQL error.** DMEC
	Error message. Event not found
4711	**MySQL error.** DMEC
	Error message. Creation of event failed
4712	**MySQL error.** DMEC
	Error message. Stopped event operation does not exist. Already stopped?
4714	**MySQL error.** DMEC
	Error message. Index stats sys tables NDB_INDEX_STAT_PREFIX do not exist
4715	**MySQL error.** DMEC
	Error message. Index stats for specified index do not exist
4716	**MySQL error.** DMEC

	Error message. Index stats methods usage error
4717	**MySQL error.** DMEC
	Error message. Index stats cannot allocate memory
4720	**MySQL error.** DMEC
	Error message. Index stats sys tables NDB_INDEX_STAT_PREFIX partly missing or invalid
4723	**MySQL error.** DMEC
	Error message. Mysqld: index stats request ignored due to recent error
4724	**MySQL error.** DMEC
	Error message. Mysqld: index stats request aborted by stats thread
4725	**MySQL error.** DMEC
	Error message. Index stats were deleted by another process
720	**MySQL error.** DMEC
	Error message. Attribute name reused in table definition
763	**MySQL error.** DMEC
	Error message. DDL is not supported with mixed data-node versions
771	**MySQL error.** HA_WRONG_CREATE_OPTION
	Error message. Given NODEGROUP doesn't exist in this cluster
776	**MySQL error.** DMEC
	Error message. Index created on temporary table must itself be temporary
777	**MySQL error.** DMEC
	Error message. Cannot create a temporary index on a non-temporary table
778	**MySQL error.** DMEC
	Error message. A temporary table or index must be specified as not logging
789	**MySQL error.** HA_WRONG_CREATE_OPTION
	Error message. Logfile group not found
793	**MySQL error.** DMEC
	Error message. Object definition too big
794	**MySQL error.** DMEC

	Error message. Schema feature requires data node upgrade
798	**MySQL error.** DMEC
	Error message. A disk table must not be specified as no logging
823	**MySQL error.** DMEC
	Error message. Too much attrinfo from application in tuple manager
829	**MySQL error.** DMEC
	Error message. Corrupt data received for insert/update
831	**MySQL error.** DMEC
	Error message. Too many nullable/bitfields in table definition
850	**MySQL error.** DMEC
	Error message. Too long or too short default value
851	**MySQL error.** DMEC
	Error message. Fixed-size column offset exceeded max.Use VARCHAR or COLUMN_FORMAT DYNAMIC for memory-stored columns
874	**MySQL error.** DMEC
	Error message. Too much attrinfo (e.g. scan filter) for scan in tuple manager
876	**MySQL error.** DMEC
	Error message. 876
877	**MySQL error.** DMEC
	Error message. 877
878	**MySQL error.** DMEC
	Error message. 878
879	**MySQL error.** DMEC
	Error message. 879
880	**MySQL error.** DMEC
	Error message. Tried to read too much - too many getValue calls
884	**MySQL error.** DMEC
	Error message. Stack overflow in interpreter
885	**MySQL error.** DMEC
	Error message. Stack underflow in interpreter

886 **MySQL error.** DMEC

Error message. More than 65535 instructions executed in interpreter

892 **MySQL error.** DMEC

Error message. Unsupported type in scan filter

897 **MySQL error.** DMEC

Error message. Update attempt of primary key via ndbcluster internal api (if this occurs via the MySQL server it is a bug, please report)

912 **MySQL error.** DMEC

Error message. Index stat scan requested with wrong lock mode

913 **MySQL error.** DMEC

Error message. Invalid index for index stats update

920 **MySQL error.** DMEC

Error message. Row operation defined after refreshTuple()

INVALID_BLOCK_NAME **MySQL error.** DMEC

Error message. Invalid block name

INVALID_ERROR_NUMBER **MySQL error.** DMEC

Error message. Invalid error number. Should be >= 0.

INVALID_TRACE_NUMBER **MySQL error.** DMEC

Error message. Invalid trace number.

NODE_NOT_API_NODE **MySQL error.** DMEC

Error message. The specified node is not an API node.

NODE_SHUTDOWN_IN_PROGESS **MySQL error.** DMEC

Error message. Node shutdown in progress

NODE_SHUTDOWN_WOULD_CAUSE_SYSTEM_CRASH **MySQL error.** DMEC

Error message. Node shutdown would cause system crash

NO_CONTACT_WITH_DB_NODES **MySQL error.** DMEC

Error message. No contact with database nodes }

NO_CONTACT_WITH_PROCESS **MySQL error.** DMEC

Error message. No contact with the process (dead ?).

OPERATION_NOT_ALLOWED_START_STOP **MySQL error.** DMEC

Error message. Operation not allowed while nodes are starting or stopping.

QRY_BATCH_SIZE_TOO_SMALL **MySQL error.** DMEC

Error message. Batch size for sub scan cannot be smaller than number of fragments.

QRY_CHAR_OPERAND_TRUNCATED **MySQL error.** DMEC

Error message. Character operand was right truncated

QRY_CHAR_PARAMETER_TRUNCATED **MySQL error.** DMEC

Error message. Character Parameter was right truncated

QRY_DEFINITION_TOO_LARGE **MySQL error.** DMEC

Error message. Query definition too large.

QRY_EMPTY_PROJECTION **MySQL error.** DMEC

Error message. Query has operation with empty projection.

QRY_HAS_ZERO_OPERATIONS **MySQL error.** DMEC

Error message. Query defintion should have at least one operation.

QRY_ILLEGAL_STATE **MySQL error.** DMEC

Error message. Query is in illegal state for this operation.

QRY_IN_ERROR_STATE **MySQL error.** DMEC

Error message. A previous query operation failed, which you missed to catch.

QRY_MULTIPLE_PARENTS **MySQL error.** DMEC

Error message. Multiple 'parents' specified in linkedValues for this operation

QRY_MULTIPLE_SCAN_SORTED **MySQL error.** DMEC

Error message. Query with multiple scans may not be sorted.

QRY_NEST_NOT_SPECIFIED **MySQL error.** DMEC

Error message. Outer joined scans need FirstInner/Upper to be specified

QRY_NEST_NOT_SPECIFIED **MySQL error.** DMEC

Error message. FirstInner/Upper has to be an ancestor or a sibling

QRY_NUM_OPERAND_RANGE **MySQL error.** DMEC

Error message. Numeric operand out of range

QRY_OJ_NOT_SUPPORTED **MySQL error.** DMEC

Error message. Outer joined scans not supported by data nodes.

QRY_OPERAND_ALREADY_BOUND **MySQL error.** DMEC

	Error message. Can't use same operand value to specify different column values
QRY_OPERAND_HAS_WRONG_TYPE	**MySQL error.** DMEC
	Error message. Incompatible datatype specified in operand argument
QRY_PARAMETER_HAS_WRONG_TYPE	**MySQL error.** DMEC
	Error message. Parameter value has an incompatible datatype
QRY_REQ_ARG_IS_NULL	**MySQL error.** DMEC
	Error message. Required argument is NULL
QRY_RESULT_ROW_ALREADY_DEFINED	**MySQL error.** DMEC
	Error message. Result row already defined for NdbQueryOperation.
QRY_SCAN_ORDER_ALREADY_SET	**MySQL error.** DMEC
	Error message. Index scan order was already set in query definition.
QRY_SEQUENTIAL_SCAN_SORTED	**MySQL error.** DMEC
	Error message. Parallelism cannot be restricted for sorted scans.
QRY_TOO_FEW_KEY_VALUES	**MySQL error.** DMEC
	Error message. All required 'key' values was not specified
QRY_TOO_MANY_KEY_VALUES	**MySQL error.** DMEC
	Error message. Too many 'key' or 'bound' values was specified
QRY_UNKNOWN_PARENT	**MySQL error.** DMEC
	Error message. Unknown 'parent' specified in linkedValue
QRY_UNRELATED_INDEX	**MySQL error.** DMEC
	Error message. Specified 'index' does not belong to specified 'table'
QRY_WRONG_INDEX_TYPE	**MySQL error.** DMEC
	Error message. Wrong type of index specified for this operation
QRY_WRONG_OPERATION_TYPE	**MySQL error.** DMEC
	Error message. This method cannot be invoked on this type of operation (lookup/scan/index scan).
SEND_OR_RECEIVE_FAILED	**MySQL error.** DMEC
	Error message. Send to process or receive failed.
SYSTEM_SHUTDOWN_IN_PROGRESS	**MySQL error.** DMEC

Error message. System shutdown in progress

UNSUPPORTED_NODE_SHUTDOWN **MySQL error.** DMEC

Error message. Unsupported multi node shutdown. Abort option required.

WRONG_PROCESS_TYPE **MySQL error.** DMEC

Error message. The process has wrong type. Expected a DB process.

2.4.2.3 No data found

The following list enumerates all `NDB` errors of type `ND` (**`No data found`**).

626 **MySQL error.** HA_ERR_KEY_NOT_FOUND

Error message. Tuple did not exist

2.4.2.4 Constraint violation

The following list enumerates all `NDB` errors of type `CV` (**`Constraint violation`**).

255 **MySQL error.** HA_ERR_NO_REFERENCED_ROW

Error message. Foreign key constraint violated: No parent row found

256 **MySQL error.** HA_ERR_ROW_IS_REFERENCED

Error message. Foreign key constraint violated: Referenced row exists

630 **MySQL error.** HA_ERR_FOUND_DUPP_KEY

Error message. Tuple already existed when attempting to insert

839 **MySQL error.** DMEC

Error message. Illegal null attribute

840 **MySQL error.** DMEC

Error message. Trying to set a NOT NULL attribute to NULL

893 **MySQL error.** HA_ERR_FOUND_DUPP_KEY

Error message. Constraint violation e.g. duplicate value in unique index

2.4.2.5 Schema error

The following list enumerates all `NDB` errors of type `SE` (**`Schema error`**).

1224 **MySQL error.** HA_WRONG_CREATE_OPTION

Error message. Too many fragments

1225 **MySQL error.** DMEC

Error message. Table not defined in local query handler

1226 **MySQL error.** HA_ERR_NO_SUCH_TABLE

Error message. Table is being dropped

1227 **MySQL error.** HA_WRONG_CREATE_OPTION

Error message. Invalid schema version

1228 **MySQL error.** DMEC

Error message. Cannot use drop table for drop index

1229 **MySQL error.** DMEC

Error message. Too long frm data supplied

1231 **MySQL error.** DMEC

Error message. Invalid table or index to scan

1232 **MySQL error.** DMEC

Error message. Invalid table or index to scan

1407 **MySQL error.** DMEC

Error message. Subscription not found in subscriber manager

1415 **MySQL error.** DMEC

Error message. Subscription not unique in subscriber manager

1417 **MySQL error.** DMEC

Error message. Table in suscription not defined, probably dropped

1418 **MySQL error.** DMEC

Error message. Subscription dropped, no new subscribers allowed

1419 **MySQL error.** DMEC

Error message. Subscription already dropped

1421 **MySQL error.** DMEC

Error message. Partially connected API in NdbOperation::execute()

1422 **MySQL error.** DMEC

Error message. Out of subscription records

1423 **MySQL error.** DMEC

Error message. Out of table records in SUMA

1424 **MySQL error.** DMEC

Error message. Out of MaxNoOfConcurrentSubOperations

1425 **MySQL error.** DMEC

Error message. Subscription being defined...while trying to stop subscriber

1426 **MySQL error.** DMEC

Error message. No such subscriber

1503 **MySQL error.** DMEC

Error message. Out of filegroup records

1504 **MySQL error.** DMEC

Error message. Out of logbuffer memory(specify smaller undo_buffer_size or increase SharedGlobalMemory)

1508 **MySQL error.** DMEC

Error message. Out of file records

1509 **MySQL error.** DMEC

Error message. File system error, check if path,permissions etc

1512 **MySQL error.** DMEC

Error message. File read error

1514 **MySQL error.** DMEC

Error message. Currently there is a limit of one logfile group

1515 **MySQL error.** DMEC

Error message. Currently there is a 4G limit of one undo/data-file in 32-bit host

1516 **MySQL error.** DMEC

Error message. File too small

1517 **MySQL error.** DMEC

Error message. Insufficient disk page buffer memory. Increase DiskPageBufferMemory or reduce data file size.

20019 **MySQL error.** HA_ERR_NO_SUCH_TABLE

Error message. Query table not defined

20020 **MySQL error.** HA_ERR_NO_SUCH_TABLE

Error message. Query table is being dropped

20021 **MySQL error.** HA_ERR_TABLE_DEF_CHANGED

Error message. Query table definition has changed

21022 **MySQL error.** DMEC

Error message. Create foreign key failed in NDB - parent table is not table

21023 **MySQL error.** DMEC

Error message. Create foreign key failed in NDB - invalid parent table version

21024 **MySQL error.** DMEC

Error message. Create foreign key failed in NDB - child table is not table

21025 **MySQL error.** DMEC

Error message. Create foreign key failed in NDB - invalid child table version

21027 **MySQL error.** DMEC

Error message. Create foreign key failed in NDB - invalid parent index version

21028 **MySQL error.** DMEC

Error message. Create foreign key failed in NDB - child index is not index

21029 **MySQL error.** DMEC

Error message. Create foreign key failed in NDB - invalid child index version

21041 **MySQL error.** DMEC

Error message. Drop foreign key failed in NDB - invalid foreign key version

21042 **MySQL error.** DMEC

Error message. Drop foreign key failed in NDB - foreign key not found in TC

21061 **MySQL error.** DMEC

Error message. Build foreign key failed in NDB - invalid foreign key version

241 **MySQL error.** HA_ERR_TABLE_DEF_CHANGED

Error message. Invalid schema object version

283 **MySQL error.** HA_ERR_NO_SUCH_TABLE

Error message. Table is being dropped

284 **MySQL error.** HA_ERR_TABLE_DEF_CHANGED

Error message. Table not defined in transaction coordinator

285 **MySQL error.** DMEC

Error message. Unknown table error in transaction coordinator

4713 **MySQL error.** DMEC

Error message. Column defined in event does not exist in table

703 **MySQL error.** DMEC

Error message. Invalid table format

704 **MySQL error.** DMEC

Error message. Attribute name too long

705 **MySQL error.** DMEC

Error message. Table name too long

707 **MySQL error.** DMEC

Error message. No more table metadata records (increase MaxNoOfTables)

708 **MySQL error.** DMEC

Error message. No more attribute metadata records (increase MaxNoOfAttributes)

709 **MySQL error.** HA_ERR_NO_SUCH_TABLE

Error message. No such table existed

710 **MySQL error.** DMEC

Error message. Internal: Get by table name not supported, use table id.

712 **MySQL error.** DMEC

Error message. No more hashmap metadata records

723 **MySQL error.** HA_ERR_NO_SUCH_TABLE

Error message. No such table existed

736 **MySQL error.** DMEC

Error message. Unsupported array size

737 **MySQL error.** HA_WRONG_CREATE_OPTION

Error message. Attribute array size too big

738 **MySQL error.** HA_WRONG_CREATE_OPTION

Error message. Record too big

739 **MySQL error.** HA_WRONG_CREATE_OPTION

Error message. Unsupported primary key length

740 **MySQL error.** HA_WRONG_CREATE_OPTION

Error message. Nullable primary key not supported

741 **MySQL error.** DMEC

Error message. Unsupported alter table

743 **MySQL error.** HA_WRONG_CREATE_OPTION

	Error message. Unsupported character set in table or index
744	**MySQL error.** DMEC
	Error message. Character string is invalid for given character set
745	**MySQL error.** HA_WRONG_CREATE_OPTION
	Error message. Distribution key not supported for char attribute (use binary attribute)
750	**MySQL error.** IE
	Error message. Invalid file type
751	**MySQL error.** DMEC
	Error message. Out of file records
752	**MySQL error.** DMEC
	Error message. Invalid file format
753	**MySQL error.** IE
	Error message. Invalid filegroup for file
754	**MySQL error.** IE
	Error message. Invalid filegroup version when creating file
755	**MySQL error.** HA_MISSING_CREATE_OPTION
	Error message. Invalid tablespace
756	**MySQL error.** DMEC
	Error message. Index on disk column is not supported
757	**MySQL error.** DMEC
	Error message. Varsize bitfield not supported
758	**MySQL error.** DMEC
	Error message. Tablespace has changed
759	**MySQL error.** DMEC
	Error message. Invalid tablespace version
760	**MySQL error.** DMEC
	Error message. File already exists,
761	**MySQL error.** DMEC
	Error message. Unable to drop table as backup is in progress
762	**MySQL error.** DMEC
	Error message. Unable to alter table as backup is in progress
764	**MySQL error.** HA_WRONG_CREATE_OPTION

Error message. Invalid extent size

765 **MySQL error.** DMEC

Error message. Out of filegroup records

766 **MySQL error.** DMEC

Error message. Cant drop file, no such file

767 **MySQL error.** DMEC

Error message. Cant drop filegroup, no such filegroup

768 **MySQL error.** DMEC

Error message. Cant drop filegroup, filegroup is used

769 **MySQL error.** DMEC

Error message. Drop undofile not supported, drop logfile group instead

770 **MySQL error.** DMEC

Error message. Cant drop file, file is used

773 **MySQL error.** DMEC

Error message. Out of string memory, please modify StringMemory config parameter

774 **MySQL error.** DMEC

Error message. Invalid schema object for drop

775 **MySQL error.** DMEC

Error message. Create file is not supported when Diskless=1

779 **MySQL error.** HA_WRONG_CREATE_OPTION

Error message. Invalid undo buffer size

790 **MySQL error.** HA_WRONG_CREATE_OPTION

Error message. Invalid hashmap

791 **MySQL error.** HA_WRONG_CREATE_OPTION

Error message. Too many total bits in bitfields

792 **MySQL error.** DMEC

Error message. Default value for primary key column not supported

796 **MySQL error.** DMEC

Error message. Out of schema transaction memory

799 **MySQL error.** HA_WRONG_CREATE_OPTION

Error message. Non default partitioning without partitions

881	**MySQL error.** DMEC **Error message.** Unable to create table, out of data pages (increase DataMemory)
906	**MySQL error.** DMEC **Error message.** Unsupported attribute type in index
907	**MySQL error.** DMEC **Error message.** Unsupported character set in table or index
910	**MySQL error.** HA_ERR_NO_SUCH_TABLE **Error message.** Index is being dropped
911	**MySQL error.** DMEC **Error message.** Index stat scan requested on index with unsupported key size

2.4.2.6 Schema object already exists

The following list enumerates all `NDB` errors of type `OE` (**`Schema object already exists`**).

4244	**MySQL error.** HA_ERR_TABLE_EXIST **Error message.** Index or table with given name already exists
721	**MySQL error.** HA_ERR_TABLE_EXIST **Error message.** Schema object with given name already exists
746	**MySQL error.** DMEC **Error message.** Event name already exists

2.4.2.7 User defined error

The following list enumerates all `NDB` errors of type `UD` (**`User defined error`**).

1321	**MySQL error.** DMEC **Error message.** Backup aborted by user request
4260	**MySQL error.** DMEC **Error message.** NdbScanFilter: Operator is not defined in NdbScanFilter::Group
4261	**MySQL error.** DMEC **Error message.** NdbScanFilter: Column is NULL
4262	**MySQL error.** DMEC **Error message.** NdbScanFilter: Condition is out of bounds

2.4.2.8 Insufficient space

The following list enumerates all `NDB` errors of type `IS` (**`Insufficient space`**).

1303	**MySQL error.** DMEC **Error message.** Out of resources
1412	**MySQL error.** DMEC **Error message.** Can't accept more subscribers, out of space in pool
1416	**MySQL error.** DMEC **Error message.** Can't accept more subscriptions, out of space in pool
1601	**MySQL error.** HA_ERR_RECORD_FILE_FULL **Error message.** Out of extents, tablespace full
1602	**MySQL error.** DMEC **Error message.** No datafile in tablespace
1603	**MySQL error.** HA_ERR_RECORD_FILE_FULL **Error message.** Table fragment fixed data reference has reached maximum possible value (specify MAXROWS or increase no of partitions)
1604	**MySQL error.** DMEC **Error message.** Error -1 from get_page
1605	**MySQL error.** HA_ERR_RECORD_FILE_FULL **Error message.** Out of page request records when allocating disk record
1606	**MySQL error.** HA_ERR_RECORD_FILE_FULL **Error message.** Out of extent records when allocating disk record
623	**MySQL error.** HA_ERR_RECORD_FILE_FULL **Error message.** 623
624	**MySQL error.** HA_ERR_RECORD_FILE_FULL **Error message.** 624
625	**MySQL error.** HA_ERR_INDEX_FILE_FULL **Error message.** Out of memory in Ndb Kernel, hash index part (increase DataMemory)
633	**MySQL error.** HA_ERR_INDEX_FILE_FULL **Error message.** Table fragment hash index has reached maximum possible size
640	**MySQL error.** DMEC **Error message.** Too many hash indexes (should not happen)

747	**MySQL error.** DMEC **Error message.** Out of event records
826	**MySQL error.** HA_ERR_RECORD_FILE_FULL **Error message.** Too many tables and attributes (increase MaxNoOfAttributes or MaxNoOfTables)
827	**MySQL error.** HA_ERR_RECORD_FILE_FULL **Error message.** Out of memory in Ndb Kernel, table data (increase DataMemory)
889	**MySQL error.** HA_ERR_RECORD_FILE_FULL **Error message.** Table fragment fixed data reference has reached maximum possible value (specify MAXROWS or increase no of partitions)
902	**MySQL error.** HA_ERR_RECORD_FILE_FULL **Error message.** Out of memory in Ndb Kernel, ordered index data (increase DataMemory)
903	**MySQL error.** HA_ERR_INDEX_FILE_FULL **Error message.** Too many ordered indexes (increase MaxNoOfOrderedIndexes)
904	**MySQL error.** HA_ERR_INDEX_FILE_FULL **Error message.** Out of fragment records (increase MaxNoOfOrderedIndexes)
905	**MySQL error.** DMEC **Error message.** Out of attribute records (increase MaxNoOfAttributes)
908	**MySQL error.** DMEC **Error message.** Invalid ordered index tree node size

2.4.2.9 Temporary Resource error

The following list enumerates all `NDB` errors of type `TR` (**`Temporary Resource error`**).

1217	**MySQL error.** DMEC **Error message.** Out of operation records in local data manager (increase SharedGlobalMemory)
1218	**MySQL error.** DMEC **Error message.** Send Buffers overloaded in NDB kernel
1220	**MySQL error.** DMEC **Error message.** REDO log files overloaded (increase FragmentLogFileSize)
1222	**MySQL error.** DMEC

	Error message. Out of transaction markers in LQH, increase SharedGlobalMemory
1234	**MySQL error.** DMEC
	Error message. REDO log files overloaded (increase disk hardware)
1350	**MySQL error.** DMEC
	Error message. Backup failed: file already exists (use 'START BACKUP <backup id>')
1411	**MySQL error.** DMEC
	Error message. Subscriber manager busy with adding/removing a subscriber
1413	**MySQL error.** DMEC
	Error message. Subscriber manager busy with adding the subscription
1414	**MySQL error.** DMEC
	Error message. Subscriber manager has subscribers on this subscription
1420	**MySQL error.** DMEC
	Error message. Subscriber manager busy with adding/removing a table
1501	**MySQL error.** DMEC
	Error message. Out of undo space
20000	**MySQL error.** DMEC
	Error message. Query aborted due out of operation records
20006	**MySQL error.** DMEC
	Error message. Query aborted due to out of LongMessageBuffer
20008	**MySQL error.** DMEC
	Error message. Query aborted due to out of query memory
20015	**MySQL error.** DMEC
	Error message. Query aborted due to out of row memory
21020	**MySQL error.** DMEC
	Error message. Create foreign key failed in NDB - no more object records
217	**MySQL error.** DMEC
	Error message. 217
218	**MySQL error.** DMEC

	Error message. Out of LongMessageBuffer
219	**MySQL error.** DMEC
	Error message. 219
221	**MySQL error.** DMEC
	Error message. Too many concurrently fired triggers, increase SharedGlobalMemory
233	**MySQL error.** DMEC
	Error message. Out of operation records in transaction coordinator (increase SharedGlobalMemory)
245	**MySQL error.** DMEC
	Error message. Too many active scans, increase MaxNoOfConcurrentScans
251	**MySQL error.** DMEC
	Error message. Out of frag location records in TC (increase SharedGlobalMemory)
273	**MySQL error.** DMEC
	Error message. Out of transaction markers databuffer in TC, increase SharedGlobalMemory
275	**MySQL error.** DMEC
	Error message. Out of transaction records for complete phase (increase SharedGlobalMemory)
279	**MySQL error.** DMEC
	Error message. Out of transaction markers in TC, increase SharedGlobalMemory
2810	**MySQL error.** DMEC
	Error message. No space left on the device
2811	**MySQL error.** DMEC
	Error message. Error with file permissions, please check file system
2815	**MySQL error.** DMEC
	Error message. Error in reading files, please check file system
288	**MySQL error.** DMEC
	Error message. Out of index operations in transaction coordinator (increase SharedGlobalMemory)
289	**MySQL error.** DMEC
	Error message. Out of transaction buffer memory in TC (increase SharedGlobalMemory)

291	**MySQL error.** DMEC **Error message.** Out of scanfrag records in TC (increase SharedGlobalMemory)
293	**MySQL error.** DMEC **Error message.** Out of attribute buffers in TC block, increase SharedGlobalMemory
312	**MySQL error.** DMEC **Error message.** Out of LongMessageBuffer
4021	**MySQL error.** DMEC **Error message.** Out of Send Buffer space in NDB API
4022	**MySQL error.** DMEC **Error message.** Out of Send Buffer space in NDB API
4032	**MySQL error.** DMEC **Error message.** Out of Send Buffer space in NDB API
414	**MySQL error.** DMEC **Error message.** 414
418	**MySQL error.** DMEC **Error message.** Out of transaction buffers in LQH, increase LongSignalMemory
419	**MySQL error.** DMEC **Error message.** Out of signal memory, increase LongSignalMemory
488	**MySQL error.** DMEC **Error message.** Too many active scans
489	**MySQL error.** DMEC **Error message.** Out of scan records in LQH, increase SharedGlobalMemory
490	**MySQL error.** DMEC **Error message.** Too many active scans
748	**MySQL error.** DMEC **Error message.** Busy during read of event table
780	**MySQL error.** DMEC **Error message.** Too many schema transactions
783	**MySQL error.** DMEC **Error message.** Too many schema operations

784 **MySQL error.** DMEC

Error message. Invalid schema transaction state

785 **MySQL error.** DMEC

Error message. Schema object is busy with another schema transaction

788 **MySQL error.** DMEC

Error message. Missing schema operation at takeover of schema transaction

805 **MySQL error.** DMEC

Error message. Out of attrinfo records in tuple manager, increase LongSignalMemory

830 **MySQL error.** DMEC

Error message. Out of add fragment operation records

873 **MySQL error.** DMEC

Error message. Out of transaction memory in local data manager, ordered index data (increase SharedGlobalMemory)

899 **MySQL error.** DMEC

Error message. Rowid already allocated

909 **MySQL error.** DMEC

Error message. Out of transaction memory in local data manager, ordered scan operation (increase SharedGlobalMemory)

915 **MySQL error.** DMEC

Error message. No free index stats op

918 **MySQL error.** DMEC

Error message. Cannot prepare index stats update

919 **MySQL error.** DMEC

Error message. Cannot execute index stats update

921 **MySQL error.** DMEC

Error message. Out of transaction memory in local data manager, copy tuples (increase SharedGlobalMemory)

923 **MySQL error.** DMEC

Error message. Out of UNDO buffer memory (increase UNDO_BUFFER_SIZE)

924 **MySQL error.** DMEC

Error message. Out of transaction memory in local data manager, stored procedure record (increase SharedGlobalMemory)

925

MySQL error. DMEC

Error message. Out of transaction memory in local data manager, tup scan operation (increase SharedGlobalMemory)

926

MySQL error. DMEC

Error message. Out of transaction memory in local data manager, acc scan operation (increase SharedGlobalMemory)

2.4.2.10 Node Recovery error

The following list enumerates all `NDB` errors of type `NR` (**`Node Recovery error`**).

1204

MySQL error. DMEC

Error message. Temporary failure, distribution changed

1405

MySQL error. DMEC

Error message. Subscriber manager busy with node recovery

1427

MySQL error. DMEC

Error message. Api node died, when SUB_START_REQ reached node

20016

MySQL error. DMEC

Error message. Query aborted due to node failure

250

MySQL error. DMEC

Error message. Node where lock was held crashed, restart scan transaction

286

MySQL error. DMEC

Error message. Node failure caused abort of transaction

4002

MySQL error. DMEC

Error message. Send to NDB failed

4007

MySQL error. DMEC

Error message. Send to ndbd node failed

4010

MySQL error. DMEC

Error message. Node failure caused abort of transaction

4013

MySQL error. DMEC

Error message. Request timed out in waiting for node failure

4025

MySQL error. DMEC

Error message. Node failure caused abort of transaction

4027

MySQL error. DMEC

Error message. Node failure caused abort of transaction

4028

MySQL error. DMEC

Error message. Node failure caused abort of transaction

4029

MySQL error. DMEC

Error message. Node failure caused abort of transaction

4031

MySQL error. DMEC

Error message. Node failure caused abort of transaction

4033

MySQL error. DMEC

Error message. Send to NDB failed

4035

MySQL error. DMEC

Error message. Cluster temporary unavailable

4115

MySQL error. DMEC

Error message. Transaction was committed but all read information was not received due to node crash

4119

MySQL error. DMEC

Error message. Simple/dirty read failed due to node failure

499

MySQL error. DMEC

Error message. Scan take over error, restart scan transaction

631

MySQL error. DMEC

Error message. Scan take over error, restart scan transaction

786

MySQL error. DMEC

Error message. Schema transaction aborted due to node-failure

2.4.2.11 Overload error

The following list enumerates all `NDB` errors of type `OL` (**`Overload error`**).

1221

MySQL error. DMEC

Error message. REDO buffers overloaded (increase RedoBuffer)

1518

MySQL error. DMEC

Error message. IO overload error

4006

MySQL error. DMEC

Error message. Connect failure - out of connection objects (increase MaxNoOfConcurrentTransactions)

410

MySQL error. DMEC

Error message. REDO log files overloaded (decrease TimeBetweenLocalCheckpoints or increase NoOfFragmentLogFiles)

677 **MySQL error.** DMEC

Error message. Index UNDO buffers overloaded (increase UndoIndexBuffer)

701 **MySQL error.** DMEC

Error message. System busy with other schema operation

711 **MySQL error.** DMEC

Error message. System busy with node restart, schema operations not allowed

891 **MySQL error.** DMEC

Error message. Data UNDO buffers overloaded (increase UndoDataBuffer)

2.4.2.12 Timeout expired

The following list enumerates all NDB errors of type TO (**Timeout expired**).

237 **MySQL error.** HA_ERR_LOCK_WAIT_TIMEOUT

Error message. Transaction had timed out when trying to commit it

266 **MySQL error.** HA_ERR_LOCK_WAIT_TIMEOUT

Error message. Time-out in NDB, probably caused by deadlock

4351 **MySQL error.** DMEC

Error message. Timeout/deadlock during index build

5024 **MySQL error.** DMEC

Error message. Time-out due to node shutdown not starting in time

5025 **MySQL error.** DMEC

Error message. Time-out due to node shutdown not completing in time

2.4.2.13 Node shutdown

The following list enumerates all NDB errors of type NS (**Node shutdown**).

1223 **MySQL error.** DMEC

Error message. Read operation aborted due to node shutdown

270 **MySQL error.** DMEC

Error message. Transaction aborted due to node shutdown

280 **MySQL error.** DMEC

Error message. Transaction aborted due to node shutdown

4023 **MySQL error.** DMEC

Error message. Transaction aborted due to node shutdown

4030 **MySQL error.** DMEC

Error message. Transaction aborted due to node shutdown

4034 **MySQL error.** DMEC

Error message. Transaction aborted due to node shutdown

2.4.2.14 Internal temporary

The following list enumerates all `NDB` errors of type `IT` (**`Internal temporary`**).

1703 **MySQL error.** DMEC

Error message. Node failure handling not completed

1705 **MySQL error.** DMEC

Error message. Not ready for connection allocation yet

702 **MySQL error.** DMEC

Error message. Request to non-master

787 **MySQL error.** DMEC

Error message. Schema transaction aborted

2.4.2.15 Unknown result error

The following list enumerates all `NDB` errors of type `UR` (**`Unknown result error`**).

4008 **MySQL error.** DMEC

Error message. Receive from NDB failed

4009 **MySQL error.** HA_ERR_NO_CONNECTION

Error message. Cluster Failure

4012 **MySQL error.** DMEC

Error message. Request ndbd time-out, maybe due to high load or communication problems

2.4.2.16 Internal error

The following list enumerates all `NDB` errors of type `IE` (**`Internal error`**).

1300 **MySQL error.** DMEC

Error message. Undefined error

1301 **MySQL error.** DMEC

Error message. Backup issued to not master (reissue command to master)

1304 **MySQL error.** DMEC

Error message. Sequence failure

1305 **MySQL error.** DMEC

Error message. Backup definition not implemented

1322 **MySQL error.** DMEC

Error message. Backup already completed

1323 **MySQL error.** DMEC

Error message. 1323

1324 **MySQL error.** DMEC

Error message. Backup log buffer full

1325 **MySQL error.** DMEC

Error message. File or scan error

1326 **MySQL error.** DMEC

Error message. Backup aborted due to node failure

1327 **MySQL error.** DMEC

Error message. 1327

1340 **MySQL error.** DMEC

Error message. Backup undefined error

1428 **MySQL error.** DMEC

Error message. No replica to scan on this node (internal index stats error)

1429 **MySQL error.** DMEC

Error message. Subscriber node undefined in SubStartReq (config change?)

1502 **MySQL error.** DMEC

Error message. Filegroup already exists

1505 **MySQL error.** DMEC

Error message. Invalid filegroup

1506 **MySQL error.** DMEC

Error message. Invalid filegroup version

1507 **MySQL error.** DMEC

Error message. File no already inuse

1510 **MySQL error.** DMEC

Error message. File meta data error

1511 **MySQL error.** DMEC

Error message. Out of memory

1513 **MySQL error.** DMEC

Error message. Filegroup not online

1700 **MySQL error.** DMEC

Error message. Undefined error

20001 **MySQL error.** DMEC

Error message. Query aborted due to empty query tree

20002 **MySQL error.** DMEC

Error message. Query aborted due to invalid request

20003 **MySQL error.** DMEC

Error message. Query aborted due to unknown query operation

20004 **MySQL error.** DMEC

Error message. Query aborted due to invalid tree node specification

20005 **MySQL error.** DMEC

Error message. Query aborted due to invalid tree parameter specification

20007 **MySQL error.** DMEC

Error message. Query aborted due to invalid pattern

20009 **MySQL error.** DMEC

Error message. Query aborted due to query node too big

20010 **MySQL error.** DMEC

Error message. Query aborted due to query node parameters too big

20011 **MySQL error.** DMEC

Error message. Query aborted due to both tree and parameters contain interpreted program

20012 **MySQL error.** DMEC

Error message. Query aborted due to invalid tree parameter specification: Key parameter bits mismatch

20013 **MySQL error.** DMEC

Error message. Query aborted due to invalid tree parameter specification: Incorrect key parameter count

20014 **MySQL error.** DMEC

Error message. Query aborted due to internal error

20017 **MySQL error.** DMEC

	Error message. Query aborted due to invalid node count
20018	**MySQL error.** DMEC
	Error message. Query aborted due to index fragment not found
202	**MySQL error.** DMEC
	Error message. 202
203	**MySQL error.** DMEC
	Error message. 203
207	**MySQL error.** DMEC
	Error message. 207
208	**MySQL error.** DMEC
	Error message. 208
209	**MySQL error.** DMEC
	Error message. Communication problem, signal error
21021	**MySQL error.** DMEC
	Error message. Create foreign key failed in NDB - invalid request
21030	**MySQL error.** DMEC
	Error message. Create foreign key failed in NDB - object already exists in TC
21031	**MySQL error.** DMEC
	Error message. Create foreign key failed in NDB - no more object records in TC
21032	**MySQL error.** DMEC
	Error message. Create foreign key failed in NDB - invalid request to TC
220	**MySQL error.** DMEC
	Error message. 220
230	**MySQL error.** DMEC
	Error message. 230
232	**MySQL error.** DMEC
	Error message. 232
238	**MySQL error.** DMEC
	Error message. 238
240	**MySQL error.** DMEC

	Error message. Invalid data encountered during foreign key trigger execution
271	**MySQL error.** DMEC
	Error message. Simple Read transaction without any attributes to read
272	**MySQL error.** DMEC
	Error message. Update operation without any attributes to update
276	**MySQL error.** DMEC
	Error message. 276
277	**MySQL error.** DMEC
	Error message. 277
278	**MySQL error.** DMEC
	Error message. 278
287	**MySQL error.** DMEC
	Error message. Index corrupted
290	**MySQL error.** DMEC
	Error message. Corrupt key in TC, unable to xfrm
292	**MySQL error.** DMEC
	Error message. Inconsistent index state in TC block
294	**MySQL error.** DMEC
	Error message. Unlocked operation has out of range index
295	**MySQL error.** DMEC
	Error message. Unlocked operation has invalid state
298	**MySQL error.** DMEC
	Error message. Invalid distribution key
306	**MySQL error.** DMEC
	Error message. Out of fragment records in DIH
4000	**MySQL error.** DMEC
	Error message. MEMORY ALLOCATION ERROR
4001	**MySQL error.** DMEC
	Error message. Signal Definition Error
4005	**MySQL error.** DMEC
	Error message. Internal Error in NdbApi

4011

MySQL error. DMEC

Error message. Internal Error in NdbApi

4107

MySQL error. DMEC

Error message. Simple Transaction and Not Start

4108

MySQL error. DMEC

Error message. Faulty operation type

4109

MySQL error. DMEC

Error message. Faulty primary key attribute length

4110

MySQL error. DMEC

Error message. Faulty length in ATTRINFO signal

4111

MySQL error. DMEC

Error message. Status Error in NdbConnection

4113

MySQL error. DMEC

Error message. Too many operations received

416

MySQL error. DMEC

Error message. Bad state handling unlock request

4263

MySQL error. DMEC

Error message. Invalid blob attributes or invalid blob parts table

4267

MySQL error. DMEC

Error message. Corrupted blob value

4268

MySQL error. DMEC

Error message. Error in blob head update forced rollback of transaction

4269

MySQL error. DMEC

Error message. No connection to ndb management server

4270

MySQL error. DMEC

Error message. Unknown blob error

4273

MySQL error. DMEC

Error message. No blob table in dict cache

4274

MySQL error. DMEC

Error message. Corrupted main table PK in blob operation

4320

MySQL error. DMEC

Error message. Cannot use the same object twice to create table

4321 **MySQL error.** DMEC

Error message. Trying to start two schema transactions

4344 **MySQL error.** DMEC

Error message. Only DBDICT and TRIX can send requests to TRIX

4345 **MySQL error.** DMEC

Error message. TRIX block is not available yet, probably due to node failure

4346 **MySQL error.** DMEC

Error message. Internal error at index create/build

4347 **MySQL error.** DMEC

Error message. Bad state at alter index

4348 **MySQL error.** DMEC

Error message. Inconsistency detected at alter index

4349 **MySQL error.** DMEC

Error message. Inconsistency detected at index usage

4350 **MySQL error.** DMEC

Error message. Transaction already aborted

4718 **MySQL error.** DMEC

Error message. Index stats samples data or memory cache is invalid

4719 **MySQL error.** DMEC

Error message. Index stats internal error

4721 **MySQL error.** DMEC

Error message. Mysqld: index stats thread not open for requests

4722 **MySQL error.** DMEC

Error message. Mysqld: index stats entry unexpectedly not found

4731 **MySQL error.** DMEC

Error message. Event not found

632 **MySQL error.** DMEC

Error message. 632

706 **MySQL error.** DMEC

Error message. Inconsistency during table creation

749 **MySQL error.** HA_WRONG_CREATE_OPTION

Error message. Primary Table in wrong state

772 **MySQL error.** HA_WRONG_CREATE_OPTION

Error message. Given fragmentType doesn't exist

781 **MySQL error.** DMEC

Error message. Invalid schema transaction key from NDB API

782 **MySQL error.** DMEC

Error message. Invalid schema transaction id from NDB API

795 **MySQL error.** DMEC

Error message. Out of LongMessageBuffer in DICT

809 **MySQL error.** DMEC

Error message. 809

812 **MySQL error.** DMEC

Error message. 812

833 **MySQL error.** DMEC

Error message. 833

871 **MySQL error.** DMEC

Error message. 871

882 **MySQL error.** DMEC

Error message. 882

883 **MySQL error.** DMEC

Error message. 883

887 **MySQL error.** DMEC

Error message. 887

888 **MySQL error.** DMEC

Error message. 888

890 **MySQL error.** DMEC

Error message. 890

896 **MySQL error.** DMEC

Error message. Tuple corrupted - wrong checksum or column data in invalid format

901 **MySQL error.** DMEC

Error message. Inconsistent ordered index. The index needs to be dropped and recreated

914 **MySQL error.** DMEC

Error message. Invalid index stats request

916 **MySQL error.** DMEC

Error message. Invalid index stats sys tables

917 **MySQL error.** DMEC

Error message. Invalid index stats sys tables data

2.4.2.17 Function not implemented

The following list enumerates all NDB errors of type NI (**Function not implemented**).

4003 **MySQL error.** DMEC

Error message. Function not implemented yet

797 **MySQL error.** DMEC

Error message. Wrong fragment count for fully replicated table

2.4.3 NDB Error Codes: Single Listing

This section lists all NDB errors, ordered by NDB error code. Each listing also includes the error's NDB error type, the corresponding MySQL Server error, and the text of the error message.

0 **MySQL error.** **0**

NDB error type. No error

Error message. No error

1204 **MySQL error.** **DMEC**

NDB error type. Node Recovery error

Error message. Temporary failure, distribution changed

1217 **MySQL error.** **DMEC**

NDB error type. Temporary Resource error

Error message. Out of operation records in local data manager (increase SharedGlobalMemory)

1218 **MySQL error.** **DMEC**

NDB error type. Temporary Resource error

Error message. Send Buffers overloaded in NDB kernel

1220 **MySQL error.** **DMEC**

NDB error type. Temporary Resource error

Error message. REDO log files overloaded (increase FragmentLogFileSize)

1221 **MySQL error.** **DMEC**

NDB error type. Overload error

Error message. `REDO buffers overloaded (increase RedoBuffer)`

1222 **MySQL error.** **DMEC**

NDB error type. Temporary Resource error

Error message. `Out of transaction markers in LQH, increase SharedGlobalMemory`

1223 **MySQL error.** **DMEC**

NDB error type. Node shutdown

Error message. `Read operation aborted due to node shutdown`

1224 **MySQL error.** **HA_WRONG_CREATE_OPTION**

NDB error type. Schema error

Error message. `Too many fragments`

1225 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Table not defined in local query handler`

1226 **MySQL error.** **HA_ERR_NO_SUCH_TABLE**

NDB error type. Schema error

Error message. `Table is being dropped`

1227 **MySQL error.** **HA_WRONG_CREATE_OPTION**

NDB error type. Schema error

Error message. `Invalid schema version`

1228 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Cannot use drop table for drop index`

1229 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Too long frm data supplied`

1231 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Invalid table or index to scan`

1232 **MySQL error.** DMEC

NDB error type. Schema error

Error message. `Invalid table or index to scan`

1233 **MySQL error.** DMEC

NDB error type. Application error

Error message. `Table read-only`

1234 **MySQL error.** DMEC

NDB error type. Temporary Resource error

Error message. `REDO log files overloaded (increase disk hardware)`

1300 **MySQL error.** DMEC

NDB error type. Internal error

Error message. `Undefined error`

1301 **MySQL error.** DMEC

NDB error type. Internal error

Error message. `Backup issued to not master (reissue command to master)`

1302 **MySQL error.** DMEC

NDB error type. Application error

Error message. `A backup is already running`

1303 **MySQL error.** DMEC

NDB error type. Insufficient space

Error message. `Out of resources`

1304 **MySQL error.** DMEC

NDB error type. Internal error

Error message. `Sequence failure`

1305 **MySQL error.** DMEC

NDB error type. Internal error

Error message. `Backup definition not implemented`

1306 **MySQL error.** DMEC

NDB error type. Application error

Error message. `Backup not supported in diskless mode (change Diskless)`

1321 **MySQL error.** DMEC

NDB error type. User defined error

Error message. `Backup aborted by user request`

1322 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Backup already completed`

1323 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `1323`

1324 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Backup log buffer full`

1325 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `File or scan error`

1326 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Backup aborted due to node failure`

1327 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `1327`

1329 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Backup during software upgrade not supported`

1340 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Backup undefined error`

1342 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Backup failed to allocate buffers (check configuration)`

1343 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Backup failed to setup fs buffers (check configuration)

1344 **MySQL error.** DMEC

NDB error type. Application error

Error message. Backup failed to allocate tables (check configuration)

1345 **MySQL error.** DMEC

NDB error type. Application error

Error message. Backup failed to insert file header (check configuration)

1346 **MySQL error.** DMEC

NDB error type. Application error

Error message. Backup failed to insert table list (check configuration)

1347 **MySQL error.** DMEC

NDB error type. Application error

Error message. Backup failed to allocate table memory (check configuration)

1348 **MySQL error.** DMEC

NDB error type. Application error

Error message. Backup failed to allocate file record (check configuration)

1349 **MySQL error.** DMEC

NDB error type. Application error

Error message. Backup failed to allocate attribute record (check configuration)

1350 **MySQL error.** DMEC

NDB error type. Temporary Resource error

Error message. Backup failed: file already exists (use 'START BACKUP <backup id>')

1405 **MySQL error.** DMEC

NDB error type. Node Recovery error

Error message. Subscriber manager busy with node recovery

1407 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Subscription not found in subscriber manager

1411 **MySQL error.** DMEC

NDB error type. Temporary Resource error

Error message. Subscriber manager busy with adding/removing a subscriber

1412 **MySQL error.** DMEC

NDB error type. Insufficient space

Error message. Can't accept more subscribers, out of space in pool

1413 **MySQL error.** DMEC

NDB error type. Temporary Resource error

Error message. Subscriber manager busy with adding the subscription

1414 **MySQL error.** DMEC

NDB error type. Temporary Resource error

Error message. Subscriber manager has subscribers on this subscription

1415 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Subscription not unique in subscriber manager

1416 **MySQL error.** DMEC

NDB error type. Insufficient space

Error message. Can't accept more subscriptions, out of space in pool

1417 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Table in suscription not defined, probably dropped

1418 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Subscription dropped, no new subscribers allowed

1419 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Subscription already dropped

1420 **MySQL error.** **DMEC**

NDB error type. Temporary Resource error

Error message. Subscriber manager busy with adding/removing a table

1421 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. Partially connected API in NdbOperation::execute()

1422 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. Out of subscription records

1423 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. Out of table records in SUMA

1424 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. Out of MaxNoOfConcurrentSubOperations

1425 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. Subscription being defined...while trying to stop subscriber

1426 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. No such subscriber

1427 **MySQL error.** **DMEC**

NDB error type. Node Recovery error

Error message. Api node died, when SUB_START_REQ reached node

1428 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. No replica to scan on this node (internal index stats error)

1429 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Subscriber node undefined in SubStartReq (config change?)`

`1501` **MySQL error.** **`DMEC`**

NDB error type. Temporary Resource error

Error message. `Out of undo space`

`1502` **MySQL error.** **`DMEC`**

NDB error type. Internal error

Error message. `Filegroup already exists`

`1503` **MySQL error.** **`DMEC`**

NDB error type. Schema error

Error message. `Out of filegroup records`

`1504` **MySQL error.** **`DMEC`**

NDB error type. Schema error

Error message. `Out of logbuffer memory(specify smaller undo_buffer_size or increase SharedGlobalMemory)`

`1505` **MySQL error.** **`DMEC`**

NDB error type. Internal error

Error message. `Invalid filegroup`

`1506` **MySQL error.** **`DMEC`**

NDB error type. Internal error

Error message. `Invalid filegroup version`

`1507` **MySQL error.** **`DMEC`**

NDB error type. Internal error

Error message. `File no already inuse`

`1508` **MySQL error.** **`DMEC`**

NDB error type. Schema error

Error message. `Out of file records`

`1509` **MySQL error.** **`DMEC`**

NDB error type. Schema error

Error message. `File system error, check if path,permissions etc`

`1510` **MySQL error.** **`DMEC`**

NDB error type. Internal error

Error message. `File meta data error`

1511 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Out of memory`

1512 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `File read error`

1513 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Filegroup not online`

1514 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Currently there is a limit of one logfile group`

1515 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Currently there is a 4G limit of one undo/data-file in 32-bit host`

1516 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `File too small`

1517 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Insufficient disk page buffer memory. Increase DiskPageBufferMemory or reduce data file size.`

1518 **MySQL error.** **DMEC**

NDB error type. Overload error

Error message. `IO overload error`

1601 **MySQL error.** **HA_ERR_RECORD_FILE_FULL**

NDB error type. Insufficient space

Error message. `Out of extents, tablespace full`

1602 **MySQL error.** **DMEC**

NDB error type. Insufficient space

Error message. `No datafile in tablespace`

1603 **MySQL error.** `HA_ERR_RECORD_FILE_FULL`

NDB error type. Insufficient space

Error message. `Table fragment fixed data reference has reached maximum possible value (specify MAXROWS or increase no of partitions)`

1604 **MySQL error.** `DMEC`

NDB error type. Insufficient space

Error message. `Error -1 from get_page`

1605 **MySQL error.** `HA_ERR_RECORD_FILE_FULL`

NDB error type. Insufficient space

Error message. `Out of page request records when allocating disk record`

1606 **MySQL error.** `HA_ERR_RECORD_FILE_FULL`

NDB error type. Insufficient space

Error message. `Out of extent records when allocating disk record`

1700 **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `Undefined error`

1701 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Node already reserved`

1702 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Node already connected`

1703 **MySQL error.** `DMEC`

NDB error type. Internal temporary

Error message. `Node failure handling not completed`

1704 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Node type mismatch`

1705 **MySQL error.** `DMEC`

NDB error type. Internal temporary

Error message. `Not ready for connection allocation yet`

`20000` **MySQL error.** `DMEC`

NDB error type. Temporary Resource error

Error message. `Query aborted due out of operation records`

`20001` **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `Query aborted due to empty query tree`

`20002` **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `Query aborted due to invalid request`

`20003` **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `Query aborted due to unknown query operation`

`20004` **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `Query aborted due to invalid tree node specification`

`20005` **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `Query aborted due to invalid tree parameter specification`

`20006` **MySQL error.** `DMEC`

NDB error type. Temporary Resource error

Error message. `Query aborted due to out of LongMessageBuffer`

`20007` **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `Query aborted due to invalid pattern`

`20008` **MySQL error.** `DMEC`

NDB error type. Temporary Resource error

Error message. Query aborted due to out of query memory

20009

MySQL error. DMEC

NDB error type. Internal error

Error message. Query aborted due to query node too big

20010

MySQL error. DMEC

NDB error type. Internal error

Error message. Query aborted due to query node parameters too big

20011

MySQL error. DMEC

NDB error type. Internal error

Error message. Query aborted due to both tree and parameters contain interpreted program

20012

MySQL error. DMEC

NDB error type. Internal error

Error message. Query aborted due to invalid tree parameter specification: Key parameter bits mismatch

20013

MySQL error. DMEC

NDB error type. Internal error

Error message. Query aborted due to invalid tree parameter specification: Incorrect key parameter count

20014

MySQL error. DMEC

NDB error type. Internal error

Error message. Query aborted due to internal error

20015

MySQL error. DMEC

NDB error type. Temporary Resource error

Error message. Query aborted due to out of row memory

20016

MySQL error. DMEC

NDB error type. Node Recovery error

Error message. Query aborted due to node failure

20017

MySQL error. DMEC

NDB error type. Internal error

Error message. `Query aborted due to invalid node count`

`20018` **MySQL error.** **`DMEC`**

NDB error type. Internal error

Error message. `Query aborted due to index fragment not found`

`20019` **MySQL error.** **`HA_ERR_NO_SUCH_TABLE`**

NDB error type. Schema error

Error message. `Query table not defined`

`20020` **MySQL error.** **`HA_ERR_NO_SUCH_TABLE`**

NDB error type. Schema error

Error message. `Query table is being dropped`

`20021` **MySQL error.** **`HA_ERR_TABLE_DEF_CHANGED`**

NDB error type. Schema error

Error message. `Query table definition has changed`

`202` **MySQL error.** **`DMEC`**

NDB error type. Internal error

Error message. `202`

`203` **MySQL error.** **`DMEC`**

NDB error type. Internal error

Error message. `203`

`207` **MySQL error.** **`DMEC`**

NDB error type. Internal error

Error message. `207`

`208` **MySQL error.** **`DMEC`**

NDB error type. Internal error

Error message. `208`

`209` **MySQL error.** **`DMEC`**

NDB error type. Internal error

Error message. `Communication problem, signal error`

`21000` **MySQL error.** **`HA_ERR_CANNOT_ADD_FOREIGN`**

NDB error type. Application error

Error message. Create foreign key failed - parent key is primary key and on-update-cascade is not allowed

21020 **MySQL error.** DMEC

NDB error type. Temporary Resource error

Error message. Create foreign key failed in NDB - no more object records

21021 **MySQL error.** DMEC

NDB error type. Internal error

Error message. Create foreign key failed in NDB - invalid request

21022 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Create foreign key failed in NDB - parent table is not table

21023 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Create foreign key failed in NDB - invalid parent table version

21024 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Create foreign key failed in NDB - child table is not table

21025 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Create foreign key failed in NDB - invalid child table version

21026 **MySQL error.** HA_ERR_CANNOT_ADD_FOREIGN

NDB error type. Application error

Error message. Create foreign key failed in NDB - parent index is not unique index

21027 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Create foreign key failed in NDB - invalid parent index version

21028 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Create foreign key failed in NDB - child index is not index

21029 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Create foreign key failed in NDB - invalid child index version

21030 **MySQL error.** DMEC

NDB error type. Internal error

Error message. Create foreign key failed in NDB - object already exists in TC

21031 **MySQL error.** DMEC

NDB error type. Internal error

Error message. Create foreign key failed in NDB - no more object records in TC

21032 **MySQL error.** DMEC

NDB error type. Internal error

Error message. Create foreign key failed in NDB - invalid request to TC

21033 **MySQL error.** HA_ERR_CANNOT_ADD_FOREIGN

NDB error type. Application error

Error message. Create foreign key failed in NDB - No parent row found

21034 **MySQL error.** HA_ERR_CANNOT_ADD_FOREIGN

NDB error type. Application error

Error message. Create foreign key failed - child table has Blob or Text column and on-delete-cascade is not allowed

21040 **MySQL error.** DMEC

NDB error type. Application error

Error message. Drop foreign key failed in NDB - foreign key not found

21041 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Drop foreign key failed in NDB - invalid foreign key version

21042 **MySQL error.** DMEC

NDB error type. Schema error

Error message. Drop foreign key failed in NDB - foreign key not found in TC

21060

MySQL error. **DMEC**

NDB error type. Application error

Error message. Build foreign key failed in NDB - foreign key not found

21061

MySQL error. **DMEC**

NDB error type. Schema error

Error message. Build foreign key failed in NDB - invalid foreign key version

21080

MySQL error. **HA_ERR_ROW_IS_REFERENCED**

NDB error type. Application error

Error message. Drop table not allowed in NDB - referenced by foreign key on another table

21081

MySQL error. **HA_ERR_DROP_INDEX_FK**

NDB error type. Application error

Error message. Drop index not allowed in NDB - used as parent index of a foreign key

21082

MySQL error. **HA_ERR_DROP_INDEX_FK**

NDB error type. Application error

Error message. Drop index not allowed in NDB - used as child index of a foreign key

21090

MySQL error. **HA_ERR_CANNOT_ADD_FOREIGN**

NDB error type. Application error

Error message. Create foreign key failed in NDB - name contains invalid character (/)

217

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. 217

218

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. Out of LongMessageBuffer

219

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. 219

220

MySQL error. `DMEC`

NDB error type. Internal error

Error message. `220`

221

MySQL error. `DMEC`

NDB error type. Temporary Resource error

Error message. `Too many concurrently fired triggers, increase SharedGlobalMemory`

230

MySQL error. `DMEC`

NDB error type. Internal error

Error message. `230`

232

MySQL error. `DMEC`

NDB error type. Internal error

Error message. `232`

233

MySQL error. `DMEC`

NDB error type. Temporary Resource error

Error message. `Out of operation records in transaction coordinator (increase SharedGlobalMemory)`

237

MySQL error. `HA_ERR_LOCK_WAIT_TIMEOUT`

NDB error type. Timeout expired

Error message. `Transaction had timed out when trying to commit it`

238

MySQL error. `DMEC`

NDB error type. Internal error

Error message. `238`

240

MySQL error. `DMEC`

NDB error type. Internal error

Error message. `Invalid data encountered during foreign key trigger execution`

241

MySQL error. `HA_ERR_TABLE_DEF_CHANGED`

NDB error type. Schema error

Error message. `Invalid schema object version`

242

MySQL error. `DMEC`

NDB error type. Application error

Error message. `Zero concurrency in scan`

244

MySQL error. **DMEC**

NDB error type. Application error

Error message. Too high concurrency in scan

245

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. Too many active scans, increase MaxNoOfConcurrentScans

250

MySQL error. **DMEC**

NDB error type. Node Recovery error

Error message. Node where lock was held crashed, restart scan transaction

251

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. Out of frag location records in TC (increase SharedGlobalMemory)

255

MySQL error. **HA_ERR_NO_REFERENCED_ROW**

NDB error type. Constraint violation

Error message. Foreign key constraint violated: No parent row found

256

MySQL error. **HA_ERR_ROW_IS_REFERENCED**

NDB error type. Constraint violation

Error message. Foreign key constraint violated: Referenced row exists

261

MySQL error. **DMEC**

NDB error type. Application error

Error message. DML count in transaction exceeds config parameter MaxDMLOperationsPerTransaction/MaxNoOfConcurrentOperations

266

MySQL error. **HA_ERR_LOCK_WAIT_TIMEOUT**

NDB error type. Timeout expired

Error message. Time-out in NDB, probably caused by deadlock

269

MySQL error. **DMEC**

NDB error type. Application error

Error message. No condition and attributes to read in scan

270

MySQL error. **DMEC**

NDB error type. Node shutdown

Error message. `Transaction aborted due to node shutdown`

`271`

MySQL error. **`DMEC`**

NDB error type. Internal error

Error message. `Simple Read transaction without any attributes to read`

`272`

MySQL error. **`DMEC`**

NDB error type. Internal error

Error message. `Update operation without any attributes to update`

`273`

MySQL error. **`DMEC`**

NDB error type. Temporary Resource error

Error message. `Out of transaction markers databuffer in TC, increase SharedGlobalMemory`

`275`

MySQL error. **`DMEC`**

NDB error type. Temporary Resource error

Error message. `Out of transaction records for complete phase (increase SharedGlobalMemory)`

`276`

MySQL error. **`DMEC`**

NDB error type. Internal error

Error message. `276`

`277`

MySQL error. **`DMEC`**

NDB error type. Internal error

Error message. `277`

`278`

MySQL error. **`DMEC`**

NDB error type. Internal error

Error message. `278`

`279`

MySQL error. **`DMEC`**

NDB error type. Temporary Resource error

Error message. `Out of transaction markers in TC, increase SharedGlobalMemory`

280

MySQL error. **DMEC**

NDB error type. Node shutdown

Error message. Transaction aborted due to node shutdown

281

MySQL error. **HA_ERR_NO_CONNECTION**

NDB error type. Application error

Error message. Operation not allowed due to cluster shutdown in progress

2810

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. No space left on the device

2811

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. Error with file permissions, please check file system

2815

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. Error in reading files, please check file system

283

MySQL error. **HA_ERR_NO_SUCH_TABLE**

NDB error type. Schema error

Error message. Table is being dropped

284

MySQL error. **HA_ERR_TABLE_DEF_CHANGED**

NDB error type. Schema error

Error message. Table not defined in transaction coordinator

285

MySQL error. **DMEC**

NDB error type. Schema error

Error message. Unknown table error in transaction coordinator

286

MySQL error. **DMEC**

NDB error type. Node Recovery error

Error message. Node failure caused abort of transaction

287

MySQL error. **DMEC**

NDB error type. Internal error

Error message. Index corrupted

288 **MySQL error.** DMEC

NDB error type. Temporary Resource error

Error message. Out of index operations in transaction coordinator (increase SharedGlobalMemory)

289 **MySQL error.** DMEC

NDB error type. Temporary Resource error

Error message. Out of transaction buffer memory in TC (increase SharedGlobalMemory)

290 **MySQL error.** DMEC

NDB error type. Internal error

Error message. Corrupt key in TC, unable to xfrm

291 **MySQL error.** DMEC

NDB error type. Temporary Resource error

Error message. Out of scanfrag records in TC (increase SharedGlobalMemory)

292 **MySQL error.** DMEC

NDB error type. Internal error

Error message. Inconsistent index state in TC block

293 **MySQL error.** DMEC

NDB error type. Temporary Resource error

Error message. Out of attribute buffers in TC block, increase SharedGlobalMemory

294 **MySQL error.** DMEC

NDB error type. Internal error

Error message. Unlocked operation has out of range index

295 **MySQL error.** DMEC

NDB error type. Internal error

Error message. Unlocked operation has invalid state

298 **MySQL error.** DMEC

NDB error type. Internal error

Error message. Invalid distribution key

299

MySQL error. **DMEC**

NDB error type. Application error

Error message. `Operation not allowed or aborted due to single user mode`

306

MySQL error. **DMEC**

NDB error type. Internal error

Error message. `Out of fragment records in DIH`

311

MySQL error. **DMEC**

NDB error type. Application error

Error message. `Undefined partition used in setPartitionId`

312

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. `Out of LongMessageBuffer`

320

MySQL error. **DMEC**

NDB error type. Application error

Error message. `Invalid no of nodes specified for new nodegroup`

321

MySQL error. **DMEC**

NDB error type. Application error

Error message. `Invalid nodegroup id`

322

MySQL error. **DMEC**

NDB error type. Application error

Error message. `Invalid node(s) specified for new nodegroup, node already in nodegroup`

323

MySQL error. **DMEC**

NDB error type. Application error

Error message. `Invalid nodegroup id, nodegroup already existing`

324

MySQL error. **DMEC**

NDB error type. Application error

Error message. `Invalid node(s) specified for new nodegroup, no node in nodegroup is started`

325

MySQL error. **DMEC**

NDB error type. Application error

Error message. `Invalid node(s) specified for new nodegroup, node ID invalid or undefined`

`4000` **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `MEMORY ALLOCATION ERROR`

`4001` **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `Signal Definition Error`

`4002` **MySQL error.** `DMEC`

NDB error type. Node Recovery error

Error message. `Send to NDB failed`

`4003` **MySQL error.** `DMEC`

NDB error type. Function not implemented

Error message. `Function not implemented yet`

`4004` **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Attribute name or id not found in the table`

`4005` **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `Internal Error in NdbApi`

`4006` **MySQL error.** `DMEC`

NDB error type. Overload error

Error message. `Connect failure - out of connection objects (increase MaxNoOfConcurrentTransactions)`

`4007` **MySQL error.** `DMEC`

NDB error type. Node Recovery error

Error message. `Send to ndbd node failed`

`4008` **MySQL error.** `DMEC`

NDB error type. Unknown result error

Error message. `Receive from NDB failed`

4009 **MySQL error.** `HA_ERR_NO_CONNECTION`

NDB error type. Unknown result error

Error message. `Cluster Failure`

4010 **MySQL error.** `DMEC`

NDB error type. Node Recovery error

Error message. `Node failure caused abort of transaction`

4011 **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `Internal Error in NdbApi`

4012 **MySQL error.** `DMEC`

NDB error type. Unknown result error

Error message. `Request ndbd time-out, maybe due to high load or communication problems`

4013 **MySQL error.** `DMEC`

NDB error type. Node Recovery error

Error message. `Request timed out in waiting for node failure`

4021 **MySQL error.** `DMEC`

NDB error type. Temporary Resource error

Error message. `Out of Send Buffer space in NDB API`

4022 **MySQL error.** `DMEC`

NDB error type. Temporary Resource error

Error message. `Out of Send Buffer space in NDB API`

4023 **MySQL error.** `DMEC`

NDB error type. Node shutdown

Error message. `Transaction aborted due to node shutdown`

4025 **MySQL error.** `DMEC`

NDB error type. Node Recovery error

Error message. `Node failure caused abort of transaction`

4027 **MySQL error.** **DMEC**

NDB error type. Node Recovery error

Error message. Node failure caused abort of transaction

4028 **MySQL error.** **DMEC**

NDB error type. Node Recovery error

Error message. Node failure caused abort of transaction

4029 **MySQL error.** **DMEC**

NDB error type. Node Recovery error

Error message. Node failure caused abort of transaction

4030 **MySQL error.** **DMEC**

NDB error type. Node shutdown

Error message. Transaction aborted due to node shutdown

4031 **MySQL error.** **DMEC**

NDB error type. Node Recovery error

Error message. Node failure caused abort of transaction

4032 **MySQL error.** **DMEC**

NDB error type. Temporary Resource error

Error message. Out of Send Buffer space in NDB API

4033 **MySQL error.** **DMEC**

NDB error type. Node Recovery error

Error message. Send to NDB failed

4034 **MySQL error.** **DMEC**

NDB error type. Node shutdown

Error message. Transaction aborted due to node shutdown

4035 **MySQL error.** **DMEC**

NDB error type. Node Recovery error

Error message. Cluster temporary unavailable

410 **MySQL error.** **DMEC**

NDB error type. Overload error

Error message. REDO log files overloaded (decrease TimeBetweenLocalCheckpoints or increase NoOfFragmentLogFiles)

4100 **MySQL error.** DMEC

NDB error type. Application error

Error message. Status Error in NDB

4101 **MySQL error.** DMEC

NDB error type. Application error

Error message. No connections to NDB available and connect failed

4102 **MySQL error.** DMEC

NDB error type. Application error

Error message. Type in NdbTamper not correct

4103 **MySQL error.** DMEC

NDB error type. Application error

Error message. No schema connections to NDB available and connect failed

4104 **MySQL error.** DMEC

NDB error type. Application error

Error message. Ndb Init in wrong state, destroy Ndb object and create a new

4105 **MySQL error.** DMEC

NDB error type. Application error

Error message. Too many Ndb objects

4106 **MySQL error.** DMEC

NDB error type. Application error

Error message. All Not NULL attribute have not been defined

4107 **MySQL error.** DMEC

NDB error type. Internal error

Error message. Simple Transaction and Not Start

4108 **MySQL error.** DMEC

NDB error type. Internal error

Error message. Faulty operation type

4109 **MySQL error.** DMEC

NDB error type. Internal error

Error message. `Faulty primary key attribute length`

4110 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Faulty length in ATTRINFO signal`

4111 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Status Error in NdbConnection`

4113 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Too many operations received`

4114 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Transaction is already completed`

4115 **MySQL error.** **DMEC**

NDB error type. Node Recovery error

Error message. `Transaction was committed but all read information was not received due to node crash`

4116 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Operation was not defined correctly, probably missing a key`

4117 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Could not start transporter, configuration error`

4118 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Parameter error in API call`

4119 **MySQL error.** **DMEC**

NDB error type. Node Recovery error

Error message. `Simple/dirty read failed due to node failure`

4120 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Scan already complete`

4121 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Cannot set name twice for an Ndb object`

4122 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Cannot set name after Ndb object is initialised`

4123 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Free percent out of range. Allowed range is 1-99`

414 **MySQL error.** `DMEC`

NDB error type. Temporary Resource error

Error message. `414`

416 **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `Bad state handling unlock request`

417 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Bad operation reference - double unlock`

418 **MySQL error.** `DMEC`

NDB error type. Temporary Resource error

Error message. `Out of transaction buffers in LQH, increase LongSignalMemory`

419 **MySQL error.** `DMEC`

NDB error type. Temporary Resource error

Error message. `Out of signal memory, increase LongSignalMemory`

4200 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. Status Error when defining an operation

4201 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Variable Arrays not yet supported

4202 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Set value on tuple key attribute is not allowed

4203 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Trying to set a NOT NULL attribute to NULL

4204 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Set value and Read/Delete Tuple is incompatible

4205 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. No Key attribute used to define tuple

4206 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Not allowed to equal key attribute twice

4207 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Key size is limited to 4092 bytes

4208 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Trying to read a non-stored attribute

4209 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Length parameter in equal/setValue is incorrect

4210 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Ndb sent more info than the length he specified

4211 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Inconsistency in list of NdbRecAttr-objects

4212 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Ndb reports NULL value on Not NULL attribute

4213 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Not all data of an attribute has been received

4214 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Not all attributes have been received

4215 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. More data received than reported in TCKEYCONF message

4216 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. More than 8052 bytes in setValue cannot be handled

4217 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. It is not allowed to increment any other than unsigned ints

4218 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Currently not allowed to increment NULL-able attributes

4219 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Maximum size of interpretative attributes are 64 bits`

4220 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Maximum size of interpretative attributes are 64 bits`

4221 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Trying to jump to a non-defined label`

4222 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Label was not found, internal error`

4223 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Not allowed to create jumps to yourself`

4224 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Not allowed to jump to a label in a different subroutine`

4225 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `All primary keys defined, call setValue/getValue`

4226 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Bad number when defining a label`

4227 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Bad number when defining a subroutine`

4228 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Illegal interpreter function in scan definition`

4229 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Illegal register in interpreter function definition`

4230 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Illegal state when calling getValue, probably not a read`

4231 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Illegal state when calling interpreter routine`

4232 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Parallelism can only be between 1 and 240`

4233 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Calling execute (synchronous) when already prepared asynchronous transaction exists`

4234 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Illegal to call setValue in this state`

4235 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `No callback from execute`

4236 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Trigger name too long`

4237 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Too many triggers`

4238 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Trigger not found`

4239 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Trigger with given name already exists`

4240 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Unsupported trigger type`

4241 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Index name too long`

4242 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Too many indexes`

4243 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Index not found`

4244 **MySQL error.** **HA_ERR_TABLE_EXIST**

NDB error type. Schema object already exists

Error message. `Index or table with given name already exists`

4247 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Illegal index/trigger create/drop/alter request`

4248 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Trigger/index name invalid`

4249 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Invalid table`

4250 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Invalid index type or index logging option`

4251

MySQL error. **`HA_ERR_FOUND_DUPP_UNIQUE`**

NDB error type. Application error

Error message. `Cannot create unique index, duplicate keys found`

4252

MySQL error. **`DMEC`**

NDB error type. Application error

Error message. `Failed to allocate space for index`

4253

MySQL error. **`DMEC`**

NDB error type. Application error

Error message. `Failed to create index table`

4254

MySQL error. **`DMEC`**

NDB error type. Application error

Error message. `Table not an index table`

4255

MySQL error. **`DMEC`**

NDB error type. Application error

Error message. `Hash index attributes must be specified in same order as table attributes`

4256

MySQL error. **`DMEC`**

NDB error type. Application error

Error message. `Must call Ndb::init() before this function`

4257

MySQL error. **`DMEC`**

NDB error type. Application error

Error message. `Tried to read too much - too many getValue calls`

4258

MySQL error. **`DMEC`**

NDB error type. Application error

Error message. `Cannot create unique index, duplicate attributes found in definition`

4259

MySQL error. **`DMEC`**

NDB error type. Application error

Error message. `Invalid set of range scan bounds`

4260

MySQL error. DMEC

NDB error type. User defined error

Error message. NdbScanFilter: Operator is not defined in NdbScanFilter::Group

4261

MySQL error. DMEC

NDB error type. User defined error

Error message. NdbScanFilter: Column is NULL

4262

MySQL error. DMEC

NDB error type. User defined error

Error message. NdbScanFilter: Condition is out of bounds

4263

MySQL error. DMEC

NDB error type. Internal error

Error message. Invalid blob attributes or invalid blob parts table

4264

MySQL error. DMEC

NDB error type. Application error

Error message. Invalid usage of blob attribute

4265

MySQL error. DMEC

NDB error type. Application error

Error message. The method is not valid in current blob state

4266

MySQL error. DMEC

NDB error type. Application error

Error message. Invalid blob seek position

4267

MySQL error. DMEC

NDB error type. Internal error

Error message. Corrupted blob value

4268

MySQL error. DMEC

NDB error type. Internal error

Error message. Error in blob head update forced rollback of transaction

4269

MySQL error. DMEC

NDB error type. Internal error

Error message. No connection to ndb management server

4270

MySQL error. DMEC

NDB error type. Internal error

Error message. Unknown blob error

4271

MySQL error. DMEC

NDB error type. Application error

Error message. Invalid index object, not retrieved via getIndex()

4272

MySQL error. DMEC

NDB error type. Application error

Error message. Table definition has undefined column

4273

MySQL error. DMEC

NDB error type. Internal error

Error message. No blob table in dict cache

4274

MySQL error. DMEC

NDB error type. Internal error

Error message. Corrupted main table PK in blob operation

4275

MySQL error. DMEC

NDB error type. Application error

Error message. The blob method is incompatible with operation type or lock mode

4276

MySQL error. DMEC

NDB error type. Application error

Error message. Missing NULL ptr in end of keyData list

4277

MySQL error. DMEC

NDB error type. Application error

Error message. Key part len is to small for column

4278

MySQL error. DMEC

NDB error type. Application error

Error message. Supplied buffer to small

4279 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Malformed string

4280 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Inconsistent key part length

4281 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Too many keys specified for key bound in scanIndex

4282 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. range_no not strictly increasing in ordered multi-range index scan

4283 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. key_record in index scan is not an index ndbrecord

4284 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Cannot mix NdbRecAttr and NdbRecord methods in one operation

4285 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. NULL NdbRecord pointer

4286 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Invalid range_no (must be < 4096)

4287 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. The key_record and attribute_record in primary key operation do not belong to the same table

4288 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Blob handle for column not available

4289 **MySQL error.** DMEC

NDB error type. Application error

Error message. API version mismatch or wrong sizeof(NdbDictionary::RecordSpecification)

4290 **MySQL error.** DMEC

NDB error type. Application error

Error message. Missing column specification in NdbDictionary::RecordSpecification

4291 **MySQL error.** DMEC

NDB error type. Application error

Error message. Duplicate column specification in NdbDictionary::RecordSpecification

4292 **MySQL error.** DMEC

NDB error type. Application error

Error message. NdbRecord for tuple access is not an index key NdbRecord

4293 **MySQL error.** DMEC

NDB error type. Application error

Error message. Error returned from application scanIndex() callback

4294 **MySQL error.** DMEC

NDB error type. Application error

Error message. Scan filter is too large, discarded

4295 **MySQL error.** DMEC

NDB error type. Application error

Error message. Column is NULL in Get/SetValueSpec structure

4296 **MySQL error.** DMEC

NDB error type. Application error

Error message. Invalid AbortOption

4297 **MySQL error.** DMEC

NDB error type. Application error

Error message. `Invalid or unsupported OperationOptions structure`

4298 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Invalid or unsupported ScanOptions structure`

4299 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Incorrect combination of ScanOption flags, extraGetValues ptr and numExtraGetValues`

4300 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Tuple Key Type not correct`

4301 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Fragment Type not correct`

4302 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Minimum Load Factor not correct`

4303 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Maximum Load Factor not correct`

4304 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Maximum Load Factor smaller than Minimum`

4305 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `K value must currently be set to 6`

4306 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Memory Type not correct`

4307 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Invalid table name`

4308 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Attribute Size not correct`

4309 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Fixed array too large, maximum 64000 bytes`

4310 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Attribute Type not correct`

4311 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Storage Mode not correct`

4312 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Null Attribute Type not correct`

4313 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Index only storage for non-key attribute`

4314 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Storage Type of attribute not correct`

4315 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `No more key attributes allowed after defining variable length key attribute`

4316 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Key attributes are not allowed to be NULL attributes`

4317 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. Too many primary keys defined in table

4318

MySQL error. DMEC

NDB error type. Application error

Error message. Invalid attribute name or number

4319

MySQL error. DMEC

NDB error type. Application error

Error message. createAttribute called at erroneus place

4320

MySQL error. DMEC

NDB error type. Internal error

Error message. Cannot use the same object twice to create table

4321

MySQL error. DMEC

NDB error type. Internal error

Error message. Trying to start two schema transactions

4322

MySQL error. DMEC

NDB error type. Application error

Error message. Attempt to define distribution key when not prepared to

4323

MySQL error. DMEC

NDB error type. Application error

Error message. Distribution Key set on table but not defined on first attribute

4324

MySQL error. DMEC

NDB error type. Application error

Error message. Attempt to define distribution group when not prepared to

4325

MySQL error. DMEC

NDB error type. Application error

Error message. Distribution Group set on table but not defined on first attribute

4326

MySQL error. DMEC

NDB error type. Application error

Error message. Distribution Group with erroneus number of bits

4327

MySQL error. DMEC

NDB error type. Application error

Error message. Distribution key is only supported on part of primary key

4328

MySQL error. DMEC

NDB error type. Application error

Error message. Disk memory attributes not yet supported

4329

MySQL error. DMEC

NDB error type. Application error

Error message. Variable stored attributes not yet supported

4335

MySQL error. DMEC

NDB error type. Application error

Error message. Only one autoincrement column allowed per table. Having a table without primary key uses an autoincremented hidden key, i.e. a table without a primary key can not have an autoincremented column

4340

MySQL error. DMEC

NDB error type. Application error

Error message. Result or attribute record must be a base table ndbrecord, not an index ndbrecord

4341

MySQL error. DMEC

NDB error type. Application error

Error message. Not all keys read when using option SF_OrderBy

4342

MySQL error. DMEC

NDB error type. Application error

Error message. Scan defined but not prepared

4343

MySQL error. DMEC

NDB error type. Application error

Error message. Table with blobs does not support refresh

4344

MySQL error. DMEC

NDB error type. Internal error

Error message. `Only DBDICT and TRIX can send requests to TRIX`

4345 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `TRIX block is not available yet, probably due to node failure`

4346 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Internal error at index create/build`

4347 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Bad state at alter index`

4348 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Inconsistency detected at alter index`

4349 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Inconsistency detected at index usage`

4350 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. `Transaction already aborted`

4351 **MySQL error.** **DMEC**

NDB error type. Timeout expired

Error message. `Timeout/deadlock during index build`

4400 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Status Error in NdbSchemaCon`

4401 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Only one schema operation per schema transaction`

4402

MySQL error. DMEC

NDB error type. Application error

Error message. No schema operation defined before calling execute

4410

MySQL error. DMEC

NDB error type. Application error

Error message. Schema transaction is already started

4411

MySQL error. DMEC

NDB error type. Application error

Error message. Schema transaction not possible until upgrade complete

4412

MySQL error. DMEC

NDB error type. Application error

Error message. Schema transaction is not started

4501

MySQL error. DMEC

NDB error type. Application error

Error message. Insert in hash table failed when getting table information from Ndb

4502

MySQL error. DMEC

NDB error type. Application error

Error message. GetValue not allowed in Update operation

4503

MySQL error. DMEC

NDB error type. Application error

Error message. GetValue not allowed in Insert operation

4504

MySQL error. DMEC

NDB error type. Application error

Error message. SetValue not allowed in Read operation

4505

MySQL error. DMEC

NDB error type. Application error

Error message. NULL value not allowed in primary key search

4506

MySQL error. DMEC

NDB error type. Application error

Error message. `Missing getValue/setValue when calling execute`

4507 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Missing operation request when calling execute`

4508 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `GetValue not allowed for NdbRecord defined operation`

4509 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Non SF_MultiRange scan cannot have more than one bound`

4510 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `User specified partition id not allowed for scan takeover operation`

4511 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Blobs not allowed in NdbRecord delete result record`

4512 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Incorrect combination of OperationOptions optionsPresent, extraGet/SetValues ptr and numExtraGet/SetValues`

4513 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Only one scan bound allowed for non-NdbRecord setBound() API`

4514 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Can only call setBound/equal() for an NdbIndexScanOperation`

4515 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Method not allowed for NdbRecord, use OperationOptions or ScanOptions structure instead

4516 **MySQL error.** DMEC

NDB error type. Application error

Error message. Illegal instruction in interpreted program

4517 **MySQL error.** DMEC

NDB error type. Application error

Error message. Bad label in branch instruction

4518 **MySQL error.** DMEC

NDB error type. Application error

Error message. Too many instructions in interpreted program

4519 **MySQL error.** DMEC

NDB error type. Application error

Error message. NdbInterpretedCode::finalise() not called

4520 **MySQL error.** DMEC

NDB error type. Application error

Error message. Call to undefined subroutine

4521 **MySQL error.** DMEC

NDB error type. Application error

Error message. Call to undefined subroutine, internal error

4522 **MySQL error.** DMEC

NDB error type. Application error

Error message. setBound() called twice for same key

4523 **MySQL error.** DMEC

NDB error type. Application error

Error message. Pseudo columns not supported by NdbRecord

4524 **MySQL error.** DMEC

NDB error type. Application error

Error message. NdbInterpretedCode is for different table

4535 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Attempt to set bound on non key column

4536 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. NdbScanFilter constructor taking NdbOperation is not supported for NdbRecord

4537 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Wrong API. Use NdbInterpretedCode for NdbRecord operations

4538 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. NdbInterpretedCode instruction requires that table is set

4539 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. NdbInterpretedCode not supported for operation type

4540 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Attempt to pass an Index column to createRecord. Use base table columns only

4542 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Unknown partition information type

4543 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Duplicate partitioning information supplied

4544 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Wrong partitionInfo type for table

4545 **MySQL error.** DMEC

NDB error type. Application error

Error message. Invalid or Unsupported PartitionInfo structure

4546 **MySQL error.** DMEC

NDB error type. Application error

Error message. Explicit partitioning info not allowed for table and operation

4547 **MySQL error.** DMEC

NDB error type. Application error

Error message. RecordSpecification has overlapping offsets

4548 **MySQL error.** DMEC

NDB error type. Application error

Error message. RecordSpecification has too many elements

4549 **MySQL error.** DMEC

NDB error type. Application error

Error message. getLockHandle only supported for primary key read with a lock

4550 **MySQL error.** DMEC

NDB error type. Application error

Error message. Cannot releaseLockHandle until operation executed

4551 **MySQL error.** DMEC

NDB error type. Application error

Error message. NdbLockHandle already released

4552 **MySQL error.** DMEC

NDB error type. Application error

Error message. NdbLockHandle does not belong to transaction

4553 **MySQL error.** DMEC

NDB error type. Application error

Error message. NdbLockHandle original operation not executed successfully

4554 **MySQL error.** DMEC

NDB error type. Application error

Error message. `NdbBlob can only be closed from Active state`

4555 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `NdbBlob cannot be closed with pending operations`

4556 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `RecordSpecification has illegal value in column_flags`

4557 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Column types must be identical when comparing two columns`

4600 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Transaction is already started`

4601 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `Transaction is not started`

4602 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `You must call getNdbOperation before executeScan`

4603 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `There can only be ONE operation in a scan transaction`

4604 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `takeOverScanOp, to take over a scanned row one must explicitly request keyinfo on readTuples call`

4605 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. You may only call readTuples() once for each operation

4607

MySQL error. DMEC

NDB error type. Application error

Error message. There may only be one operation in a scan transaction

4608

MySQL error. DMEC

NDB error type. Application error

Error message. You can not takeOverScan unless you have used openScanExclusive

4609

MySQL error. DMEC

NDB error type. Application error

Error message. You must call nextScanResult before trying to takeOverScan

4707

MySQL error. DMEC

NDB error type. Application error

Error message. Too many event have been defined

4708

MySQL error. DMEC

NDB error type. Application error

Error message. Event name is too long

4709

MySQL error. DMEC

NDB error type. Application error

Error message. Can't accept more subscribers

4710

MySQL error. DMEC

NDB error type. Application error

Error message. Event not found

4711

MySQL error. DMEC

NDB error type. Application error

Error message. Creation of event failed

4712

MySQL error. DMEC

NDB error type. Application error

Error message. Stopped event operation does not exist. Already stopped?

4713

MySQL error. DMEC

NDB error type. Schema error

Error message. Column defined in event does not exist in table

4714 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Index stats sys tables NDB_INDEX_STAT_PREFIX do not exist

4715 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Index stats for specified index do not exist

4716 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Index stats methods usage error

4717 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Index stats cannot allocate memory

4718 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. Index stats samples data or memory cache is invalid

4719 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. Index stats internal error

4720 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Index stats sys tables NDB_INDEX_STAT_PREFIX partly missing or invalid

4721 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. Mysqld: index stats thread not open for requests

4722

MySQL error. DMEC

NDB error type. Internal error

Error message. Mysqld: index stats entry unexpectedly not found

4723

MySQL error. DMEC

NDB error type. Application error

Error message. Mysqld: index stats request ignored due to recent error

4724

MySQL error. DMEC

NDB error type. Application error

Error message. Mysqld: index stats request aborted by stats thread

4725

MySQL error. DMEC

NDB error type. Application error

Error message. Index stats were deleted by another process

4731

MySQL error. DMEC

NDB error type. Internal error

Error message. Event not found

488

MySQL error. DMEC

NDB error type. Temporary Resource error

Error message. Too many active scans

489

MySQL error. DMEC

NDB error type. Temporary Resource error

Error message. Out of scan records in LQH, increase SharedGlobalMemory

490

MySQL error. DMEC

NDB error type. Temporary Resource error

Error message. Too many active scans

499

MySQL error. DMEC

NDB error type. Node Recovery error

Error message. Scan take over error, restart scan transaction

5024

MySQL error. DMEC

NDB error type. Timeout expired

	Error message. Time-out due to node shutdown not starting in time
5025	**MySQL error.** DMEC **NDB error type.** Timeout expired **Error message.** Time-out due to node shutdown not completing in time
623	**MySQL error.** HA_ERR_RECORD_FILE_FULL **NDB error type.** Insufficient space **Error message.** 623
624	**MySQL error.** HA_ERR_RECORD_FILE_FULL **NDB error type.** Insufficient space **Error message.** 624
625	**MySQL error.** HA_ERR_INDEX_FILE_FULL **NDB error type.** Insufficient space **Error message.** Out of memory in Ndb Kernel, hash index part (increase DataMemory)
626	**MySQL error.** HA_ERR_KEY_NOT_FOUND **NDB error type.** No data found **Error message.** Tuple did not exist
630	**MySQL error.** HA_ERR_FOUND_DUPP_KEY **NDB error type.** Constraint violation **Error message.** Tuple already existed when attempting to insert
631	**MySQL error.** DMEC **NDB error type.** Node Recovery error **Error message.** Scan take over error, restart scan transaction
632	**MySQL error.** DMEC **NDB error type.** Internal error **Error message.** 632
633	**MySQL error.** HA_ERR_INDEX_FILE_FULL **NDB error type.** Insufficient space **Error message.** Table fragment hash index has reached maximum possible size
640	**MySQL error.** DMEC

NDB error type. Insufficient space

Error message. `Too many hash indexes (should not happen)`

677 **MySQL error.** **`DMEC`**

NDB error type. Overload error

Error message. `Index UNDO buffers overloaded (increase UndoIndexBuffer)`

701 **MySQL error.** **`DMEC`**

NDB error type. Overload error

Error message. `System busy with other schema operation`

702 **MySQL error.** **`DMEC`**

NDB error type. Internal temporary

Error message. `Request to non-master`

703 **MySQL error.** **`DMEC`**

NDB error type. Schema error

Error message. `Invalid table format`

704 **MySQL error.** **`DMEC`**

NDB error type. Schema error

Error message. `Attribute name too long`

705 **MySQL error.** **`DMEC`**

NDB error type. Schema error

Error message. `Table name too long`

706 **MySQL error.** **`DMEC`**

NDB error type. Internal error

Error message. `Inconsistency during table creation`

707 **MySQL error.** **`DMEC`**

NDB error type. Schema error

Error message. `No more table metadata records (increase MaxNoOfTables)`

708 **MySQL error.** **`DMEC`**

NDB error type. Schema error

Error message. `No more attribute metadata records (increase MaxNoOfAttributes)`

709 **MySQL error.** **HA_ERR_NO_SUCH_TABLE**

NDB error type. Schema error

Error message. No such table existed

710 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. Internal: Get by table name not supported, use table id.

711 **MySQL error.** **DMEC**

NDB error type. Overload error

Error message. System busy with node restart, schema operations not allowed

712 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. No more hashmap metadata records

720 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Attribute name reused in table definition

721 **MySQL error.** **HA_ERR_TABLE_EXIST**

NDB error type. Schema object already exists

Error message. Schema object with given name already exists

723 **MySQL error.** **HA_ERR_NO_SUCH_TABLE**

NDB error type. Schema error

Error message. No such table existed

736 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. Unsupported array size

737 **MySQL error.** **HA_WRONG_CREATE_OPTION**

NDB error type. Schema error

Error message. Attribute array size too big

738 **MySQL error.** **HA_WRONG_CREATE_OPTION**

NDB error type. Schema error

Error message. Record too big

739 **MySQL error.** **HA_WRONG_CREATE_OPTION**

NDB error type. Schema error

Error message. Unsupported primary key length

740 **MySQL error.** **HA_WRONG_CREATE_OPTION**

NDB error type. Schema error

Error message. Nullable primary key not supported

741 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. Unsupported alter table

743 **MySQL error.** **HA_WRONG_CREATE_OPTION**

NDB error type. Schema error

Error message. Unsupported character set in table or index

744 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. Character string is invalid for given character set

745 **MySQL error.** **HA_WRONG_CREATE_OPTION**

NDB error type. Schema error

Error message. Distribution key not supported for char attribute (use binary attribute)

746 **MySQL error.** **DMEC**

NDB error type. Schema object already exists

Error message. Event name already exists

747 **MySQL error.** **DMEC**

NDB error type. Insufficient space

Error message. Out of event records

748 **MySQL error.** **DMEC**

NDB error type. Temporary Resource error

Error message. Busy during read of event table

749 **MySQL error.** **HA_WRONG_CREATE_OPTION**

NDB error type. Internal error

Error message. Primary Table in wrong state

750 **MySQL error.** **IE**

NDB error type. Schema error

Error message. `Invalid file type`

751 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Out of file records`

752 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Invalid file format`

753 **MySQL error.** **IE**

NDB error type. Schema error

Error message. `Invalid filegroup for file`

754 **MySQL error.** **IE**

NDB error type. Schema error

Error message. `Invalid filegroup version when creating file`

755 **MySQL error.** **HA_MISSING_CREATE_OPTION**

NDB error type. Schema error

Error message. `Invalid tablespace`

756 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Index on disk column is not supported`

757 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Varsize bitfield not supported`

758 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Tablespace has changed`

759 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Invalid tablespace version`

760 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `File already exists,`

761 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Unable to drop table as backup is in progress`

762 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Unable to alter table as backup is in progress`

763 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. `DDL is not supported with mixed data-node versions`

764 **MySQL error.** **HA_WRONG_CREATE_OPTION**

NDB error type. Schema error

Error message. `Invalid extent size`

765 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Out of filegroup records`

766 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Cant drop file, no such file`

767 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Cant drop filegroup, no such filegroup`

768 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Cant drop filegroup, filegroup is used`

769 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. `Drop undofile not supported, drop logfile group instead`

770 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. Cant drop file, file is used

771

MySQL error. **HA_WRONG_CREATE_OPTION**

NDB error type. Application error

Error message. Given NODEGROUP doesn't exist in this cluster

772

MySQL error. **HA_WRONG_CREATE_OPTION**

NDB error type. Internal error

Error message. Given fragmentType doesn't exist

773

MySQL error. **DMEC**

NDB error type. Schema error

Error message. Out of string memory, please modify StringMemory config parameter

774

MySQL error. **DMEC**

NDB error type. Schema error

Error message. Invalid schema object for drop

775

MySQL error. **DMEC**

NDB error type. Schema error

Error message. Create file is not supported when Diskless=1

776

MySQL error. **DMEC**

NDB error type. Application error

Error message. Index created on temporary table must itself be temporary

777

MySQL error. **DMEC**

NDB error type. Application error

Error message. Cannot create a temporary index on a non-temporary table

778

MySQL error. **DMEC**

NDB error type. Application error

Error message. A temporary table or index must be specified as not logging

779

MySQL error. **HA_WRONG_CREATE_OPTION**

NDB error type. Schema error

Error message. Invalid undo buffer size

780

MySQL error. `DMEC`

NDB error type. Temporary Resource error

Error message. `Too many schema transactions`

781

MySQL error. `DMEC`

NDB error type. Internal error

Error message. `Invalid schema transaction key from NDB API`

782

MySQL error. `DMEC`

NDB error type. Internal error

Error message. `Invalid schema transaction id from NDB API`

783

MySQL error. `DMEC`

NDB error type. Temporary Resource error

Error message. `Too many schema operations`

784

MySQL error. `DMEC`

NDB error type. Temporary Resource error

Error message. `Invalid schema transaction state`

785

MySQL error. `DMEC`

NDB error type. Temporary Resource error

Error message. `Schema object is busy with another schema transaction`

786

MySQL error. `DMEC`

NDB error type. Node Recovery error

Error message. `Schema transaction aborted due to node-failure`

787

MySQL error. `DMEC`

NDB error type. Internal temporary

Error message. `Schema transaction aborted`

788

MySQL error. `DMEC`

NDB error type. Temporary Resource error

Error message. `Missing schema operation at takeover of schema transaction`

789

MySQL error. `HA_WRONG_CREATE_OPTION`

NDB error type. Application error

Error message. `Logfile group not found`

790

MySQL error. `HA_WRONG_CREATE_OPTION`

NDB error type. Schema error

Error message. `Invalid hashmap`

791

MySQL error. `HA_WRONG_CREATE_OPTION`

NDB error type. Schema error

Error message. `Too many total bits in bitfields`

792

MySQL error. `DMEC`

NDB error type. Schema error

Error message. `Default value for primary key column not supported`

793

MySQL error. `DMEC`

NDB error type. Application error

Error message. `Object definition too big`

794

MySQL error. `DMEC`

NDB error type. Application error

Error message. `Schema feature requires data node upgrade`

795

MySQL error. `DMEC`

NDB error type. Internal error

Error message. `Out of LongMessageBuffer in DICT`

796

MySQL error. `DMEC`

NDB error type. Schema error

Error message. `Out of schema transaction memory`

797

MySQL error. `DMEC`

NDB error type. Function not implemented

Error message. `Wrong fragment count for fully replicated table`

798

MySQL error. `DMEC`

NDB error type. Application error

Error message. `A disk table must not be specified as no logging`

799

MySQL error. `HA_WRONG_CREATE_OPTION`

NDB error type. Schema error

Error message. `Non default partitioning without partitions`

805

MySQL error. `DMEC`

NDB error type. Temporary Resource error

Error message. `Out of attrinfo records in tuple manager, increase LongSignalMemory`

809

MySQL error. `DMEC`

NDB error type. Internal error

Error message. `809`

812

MySQL error. `DMEC`

NDB error type. Internal error

Error message. `812`

823

MySQL error. `DMEC`

NDB error type. Application error

Error message. `Too much attrinfo from application in tuple manager`

826

MySQL error. `HA_ERR_RECORD_FILE_FULL`

NDB error type. Insufficient space

Error message. `Too many tables and attributes (increase MaxNoOfAttributes or MaxNoOfTables)`

827

MySQL error. `HA_ERR_RECORD_FILE_FULL`

NDB error type. Insufficient space

Error message. `Out of memory in Ndb Kernel, table data (increase DataMemory)`

829

MySQL error. `DMEC`

NDB error type. Application error

Error message. `Corrupt data received for insert/update`

830

MySQL error. `DMEC`

NDB error type. Temporary Resource error

Error message. `Out of add fragment operation records`

831

MySQL error. `DMEC`

NDB error type. Application error

Error message. `Too many nullable/bitfields in table definition`

833

MySQL error. `DMEC`

NDB error type. Internal error

Error message. 833

839 **MySQL error.** DMEC

NDB error type. Constraint violation

Error message. Illegal null attribute

840 **MySQL error.** DMEC

NDB error type. Constraint violation

Error message. Trying to set a NOT NULL attribute to NULL

850 **MySQL error.** DMEC

NDB error type. Application error

Error message. Too long or too short default value

851 **MySQL error.** DMEC

NDB error type. Application error

Error message. Fixed-size column offset exceeded max.Use VARCHAR or COLUMN_FORMAT DYNAMIC for memory-stored columns

871 **MySQL error.** DMEC

NDB error type. Internal error

Error message. 871

873 **MySQL error.** DMEC

NDB error type. Temporary Resource error

Error message. Out of transaction memory in local data manager, ordered index data (increase SharedGlobalMemory)

874 **MySQL error.** DMEC

NDB error type. Application error

Error message. Too much attrinfo (e.g. scan filter) for scan in tuple manager

876 **MySQL error.** DMEC

NDB error type. Application error

Error message. 876

877 **MySQL error.** DMEC

NDB error type. Application error

Error message. 877

878 **MySQL error.** DMEC

NDB error type. Application error

Error message. 878

879

MySQL error. **DMEC**

NDB error type. Application error

Error message. 879

880

MySQL error. **DMEC**

NDB error type. Application error

Error message. Tried to read too much - too many getValue calls

881

MySQL error. **DMEC**

NDB error type. Schema error

Error message. Unable to create table, out of data pages (increase DataMemory)

882

MySQL error. **DMEC**

NDB error type. Internal error

Error message. 882

883

MySQL error. **DMEC**

NDB error type. Internal error

Error message. 883

884

MySQL error. **DMEC**

NDB error type. Application error

Error message. Stack overflow in interpreter

885

MySQL error. **DMEC**

NDB error type. Application error

Error message. Stack underflow in interpreter

886

MySQL error. **DMEC**

NDB error type. Application error

Error message. More than 65535 instructions executed in interpreter

887

MySQL error. **DMEC**

NDB error type. Internal error

Error message. 887

888 **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `888`

889 **MySQL error.** `HA_ERR_RECORD_FILE_FULL`

NDB error type. Insufficient space

Error message. `Table fragment fixed data reference has reached maximum possible value (specify MAXROWS or increase no of partitions)`

890 **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `890`

891 **MySQL error.** `DMEC`

NDB error type. Overload error

Error message. `Data UNDO buffers overloaded (increase UndoDataBuffer)`

892 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Unsupported type in scan filter`

893 **MySQL error.** `HA_ERR_FOUND_DUPP_KEY`

NDB error type. Constraint violation

Error message. `Constraint violation e.g. duplicate value in unique index`

896 **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. `Tuple corrupted - wrong checksum or column data in invalid format`

897 **MySQL error.** `DMEC`

NDB error type. Application error

Error message. `Update attempt of primary key via ndbcluster internal api (if this occurs via the MySQL server it is a bug, please report)`

899 **MySQL error.** `DMEC`

NDB error type. Temporary Resource error

Error message. `Rowid already allocated`

901 **MySQL error.** `DMEC`

NDB error type. Internal error

Error message. Inconsistent ordered index. The index needs to be dropped and recreated

902

MySQL error. HA_ERR_RECORD_FILE_FULL

NDB error type. Insufficient space

Error message. Out of memory in Ndb Kernel, ordered index data (increase DataMemory)

903

MySQL error. HA_ERR_INDEX_FILE_FULL

NDB error type. Insufficient space

Error message. Too many ordered indexes (increase MaxNoOfOrderedIndexes)

904

MySQL error. HA_ERR_INDEX_FILE_FULL

NDB error type. Insufficient space

Error message. Out of fragment records (increase MaxNoOfOrderedIndexes)

905

MySQL error. DMEC

NDB error type. Insufficient space

Error message. Out of attribute records (increase MaxNoOfAttributes)

906

MySQL error. DMEC

NDB error type. Schema error

Error message. Unsupported attribute type in index

907

MySQL error. DMEC

NDB error type. Schema error

Error message. Unsupported character set in table or index

908

MySQL error. DMEC

NDB error type. Insufficient space

Error message. Invalid ordered index tree node size

909

MySQL error. DMEC

NDB error type. Temporary Resource error

Error message. Out of transaction memory in local data manager, ordered scan operation (increase SharedGlobalMemory)

910

MySQL error. HA_ERR_NO_SUCH_TABLE

NDB error type. Schema error

Error message. Index is being dropped

911 **MySQL error.** **DMEC**

NDB error type. Schema error

Error message. Index stat scan requested on index with unsupported key size

912 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Index stat scan requested with wrong lock mode

913 **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Invalid index for index stats update

914 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. Invalid index stats request

915 **MySQL error.** **DMEC**

NDB error type. Temporary Resource error

Error message. No free index stats op

916 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. Invalid index stats sys tables

917 **MySQL error.** **DMEC**

NDB error type. Internal error

Error message. Invalid index stats sys tables data

918 **MySQL error.** **DMEC**

NDB error type. Temporary Resource error

Error message. Cannot prepare index stats update

919 **MySQL error.** **DMEC**

NDB error type. Temporary Resource error

Error message. Cannot execute index stats update

920

MySQL error. **DMEC**

NDB error type. Application error

Error message. Row operation defined after refreshTuple()

921

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. Out of transaction memory in local data manager, copy tuples (increase SharedGlobalMemory)

923

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. Out of UNDO buffer memory (increase UNDO_BUFFER_SIZE)

924

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. Out of transaction memory in local data manager, stored procedure record (increase SharedGlobalMemory)

925

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. Out of transaction memory in local data manager, tup scan operation (increase SharedGlobalMemory)

926

MySQL error. **DMEC**

NDB error type. Temporary Resource error

Error message. Out of transaction memory in local data manager, acc scan operation (increase SharedGlobalMemory)

INVALID_BLOCK_NAME

MySQL error. **DMEC**

NDB error type. Application error

Error message. Invalid block name

INVALID_ERROR_NUMBER

MySQL error. **DMEC**

NDB error type. Application error

Error message. Invalid error number. Should be >= 0.

INVALID_TRACE_NUMBER

MySQL error. **DMEC**

NDB error type. Application error

Error message. Invalid trace number.

NODE_NOT_API_NODE

MySQL error. **DMEC**

NDB error type. Application error

Error message. The specified node is not an API node.

NODE_SHUTDOWN_IN_PROGESS

MySQL error. **DMEC**

NDB error type. Application error

Error message. Node shutdown in progress

NODE_SHUTDOWN_WOULD_CAUSE_SYSTEM_CRASH

MySQL error. **DMEC**

NDB error type. Application error

Error message. Node shutdown would cause system crash

NO_CONTACT_WITH_DB_NODES

MySQL error. **DMEC**

NDB error type. Application error

Error message. No contact with database nodes }

NO_CONTACT_WITH_PROCESS

MySQL error. **DMEC**

NDB error type. Application error

Error message. No contact with the process (dead ?).

OPERATION_NOT_ALLOWED_START_STOP

MySQL error. **DMEC**

NDB error type. Application error

Error message. Operation not allowed while nodes are starting or stopping.

QRY_BATCH_SIZE_TOO_SMALL

MySQL error. **DMEC**

NDB error type. Application error

Error message. Batch size for sub scan cannot be smaller than number of fragments.

QRY_CHAR_OPERAND_TRUNCATED

MySQL error. **DMEC**

NDB error type. Application error

Error message. Character operand was right truncated

QRY_CHAR_PARAMETER_TRUNCATED

MySQL error. **DMEC**

NDB error type. Application error

	Error message. Character Parameter was right truncated
QRY_DEFINITION_TOO_LARGE	**MySQL error.** DMEC **NDB error type.** Application error **Error message.** Query definition too large.
QRY_EMPTY_PROJECTION	**MySQL error.** DMEC **NDB error type.** Application error **Error message.** Query has operation with empty projection.
QRY_HAS_ZERO_OPERATIONS	**MySQL error.** DMEC **NDB error type.** Application error **Error message.** Query defintion should have at least one operation.
QRY_ILLEGAL_STATE	**MySQL error.** DMEC **NDB error type.** Application error **Error message.** Query is in illegal state for this operation.
QRY_IN_ERROR_STATE	**MySQL error.** DMEC **NDB error type.** Application error **Error message.** A previous query operation failed, which you missed to catch.
QRY_MULTIPLE_PARENTS	**MySQL error.** DMEC **NDB error type.** Application error **Error message.** Multiple 'parents' specified in linkedValues for this operation
QRY_MULTIPLE_SCAN_SORTED	**MySQL error.** DMEC **NDB error type.** Application error **Error message.** Query with multiple scans may not be sorted.
QRY_NEST_NOT_SPECIFIED	**MySQL error.** DMEC **NDB error type.** Application error **Error message.** Outer joined scans need FirstInner/Upper to be specified

QRY_NEST_NOT_SPECIFIED **MySQL error.** **DMEC**

NDB error type. Application error

Error message. FirstInner/Upper has to be an ancestor or a sibling

QRY_NUM_OPERAND_RANGE **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Numeric operand out of range

QRY_OJ_NOT_SUPPORTED **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Outer joined scans not supported by data nodes.

QRY_OPERAND_ALREADY_BOUND **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Can't use same operand value to specify different column values

QRY_OPERAND_HAS_WRONG_TYPE **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Incompatible datatype specified in operand argument

QRY_PARAMETER_HAS_WRONG_TYPE **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Parameter value has an incompatible datatype

QRY_REQ_ARG_IS_NULL **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Required argument is NULL

QRY_RESULT_ROW_ALREADY_DEFINED **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Result row already defined for NdbQueryOperation.

QRY_SCAN_ORDER_ALREADY_SET **MySQL error.** **DMEC**

NDB error type. Application error

Error message. Index scan order was already set in query definition.

QRY_SEQUENTIAL_SCAN_SORTED **MySQL error.** **DMEC**

NDB error type. Application error

	Error message. `Parallelism cannot be restricted for sorted scans.`
`QRY_TOO_FEW_KEY_VALUES`	**MySQL error.** **DMEC** **NDB error type.** Application error **Error message.** `All required 'key' values was not specified`
`QRY_TOO_MANY_KEY_VALUES`	**MySQL error.** **DMEC** **NDB error type.** Application error **Error message.** `Too many 'key' or 'bound' values was specified`
`QRY_UNKNOWN_PARENT`	**MySQL error.** **DMEC** **NDB error type.** Application error **Error message.** `Unknown 'parent' specified in linkedValue`
`QRY_UNRELATED_INDEX`	**MySQL error.** **DMEC** **NDB error type.** Application error **Error message.** `Specified 'index' does not belong to specified 'table'`
`QRY_WRONG_INDEX_TYPE`	**MySQL error.** **DMEC** **NDB error type.** Application error **Error message.** `Wrong type of index specified for this operation`
`QRY_WRONG_OPERATION_TYPE`	**MySQL error.** **DMEC** **NDB error type.** Application error **Error message.** `This method cannot be invoked on this type of operation (lookup/scan/index scan).`
`SEND_OR_RECEIVE_FAILED`	**MySQL error.** **DMEC** **NDB error type.** Application error **Error message.** `Send to process or receive failed.`
`SYSTEM_SHUTDOWN_IN_PROGRESS`	**MySQL error.** **DMEC** **NDB error type.** Application error **Error message.** `System shutdown in progress`
`UNSUPPORTED_NODE_SHUTDOWN`	**MySQL error.** **DMEC** **NDB error type.** Application error **Error message.** `Unsupported multi node shutdown. Abort option required.`

`WRONG_PROCESS_TYPE`

MySQL error. **`DMEC`**

NDB error type. Application error

Error message. `The process has wrong type. Expected a DB process.`

2.4.4 NDB Error Classifications

The following table lists the classification codes used for NDB API errors, and their descriptions. These can also be found in the file `/storage/ndb/src/ndbapi/ndberror.cpp` (*NDB 7.6 and earlier*: `ndberror.c`).

Table 2.90 Classification codes for NDB API errors, with corresponding error status and description.

Classification Code	Error Status	Description
`NE`	*`Success`*	`No error`
`AE`	*`Permanent error`*	`Application error`
`CE`	*`Permanent error`*	`Configuration or application error`
`ND`	*`Permanent error`*	`No data found`
`CV`	*`Permanent error`*	`Constraint violation`
`SE`	*`Permanent error`*	`Schema error`
`OE`	*`Permanent error`*	`Schema object already exists`
`UD`	*`Permanent error`*	`User defined error`
`IS`	*`Permanent error`*	`Insufficient space`
`TR`	*`Temporary error`*	`Temporary Resource error`
`NR`	*`Temporary error`*	`Node Recovery error`
`OL`	*`Temporary error`*	`Overload error`
`TO`	*`Temporary error`*	`Timeout expired`
`NS`	*`Temporary error`*	`Node shutdown`
`IT`	*`Temporary error`*	`Internal temporary`
`UR`	*`Unknown result`*	`Unknown result error`
`UE`	*`Unknown result`*	`Unknown error code`
`IE`	*`Permanent error`*	`Internal error`
`NI`	*`Permanent error`*	`Function not implemented`
`DMEC`	*`Default MySQL error code`*	`Used for NDB errors that are not otherwise mapped to MySQL error codes`

In NDB 7.6.4 and later, you can also obtain the descriptions for the classification codes from the `error_classification` column of the `ndbinfo.error_messages` table.

2.5 NDB API Examples

This section provides code examples illustrating how to accomplish some basic tasks using the NDB API.

All of these examples can be compiled and run as provided, and produce sample output to demonstrate their effects.

Note

For an NDB API program to connect to the cluster, the cluster configuration file must have at least one [api] section that is not assigned to an SQL node and that can be accessed from the host where the NDB API application runs. You can also use an unassigned [mysqld] section for this purpose, although we recommend that you use [mysqld] sections for SQL nodes and [api] sections for NDB client programs. See NDB Cluster Configuration Files, and especially Defining SQL and Other API Nodes in an NDB Cluster, for more information.

2.5.1 NDB API Example Using Synchronous Transactions

This example illustrates the use of synchronous transactions in the NDB API. It first creates a database ndb_examples and a table api_simple (if these objects do not already exist) using the MySQL C API with an SQL node, then performs a series of basic data operations (insert, update, read, and select) on this table using the NDB API.

The compiled program takes two arguments:

1. The path to a MySQL socket file (mysqld --socket option)

2. An NDB Cluster connection string (see NDB Cluster Connection Strings)

The correct output from this program is as follows:

```
ATTR1  ATTR2
0      10
1       1
2      12
Detected that deleted tuple doesn't exist!
4      14
5       5
6      16
7       7
8      18
9       9
```

The source code for this example can be found in storage/ndb/ndbapi-examples/ndbapi_simple/ndbapi_simple.cpp in the NDB Cluster source tree, and is reproduced here:

```
/*
 *  ndbapi_simple.cpp: Using synchronous transactions in NDB API
 *
 *  Correct output from this program is:
 *
 *  ATTR1 ATTR2
 *    0    10
 *    1     1
 *    2    12
 *  Detected that deleted tuple doesn't exist!
 *    4    14
 *    5     5
 *    6    16
 *    7     7
 *    8    18
 *    9     9
 *
 */

#include <mysql.h>
#include <mysqld_error.h>
#include <NdbApi.hpp>
// Used for cout
#include <stdio.h>
#include <iostream>

static void run_application(MYSQL &, Ndb_cluster_connection &);
```

```
#define PRINT_ERROR(code,msg) \
  std::cout << "Error in " << __FILE__ << ", line: " << __LINE__ \
            << ", code: " << code \
            << ", msg: " << msg << "." << std::endl
#define MYSQLERROR(mysql) { \
  PRINT_ERROR(mysql_errno(&mysql),mysql_error(&mysql)); \
  exit(-1); }
#define APIERROR(error) { \
  PRINT_ERROR(error.code,error.message); \
  exit(-1); }

int main(int argc, char** argv)
{
  if (argc != 3)
  {
    std::cout << "Arguments are <socket mysqld> <connect_string cluster>.\n";
    exit(-1);
  }
  // ndb_init must be called first
  ndb_init();

  // connect to mysql server and cluster and run application
  {
    char * mysqld_sock  = argv[1];
    const char *connection_string = argv[2];
    // Object representing the cluster
    Ndb_cluster_connection cluster_connection(connection_string);

    // Connect to cluster management server (ndb_mgmd)
    if (cluster_connection.connect(4 /* retries               */,
       5 /* delay between retries */,
       1 /* verbose               */))
    {
      std::cout << "Cluster management server was not ready within 30 secs.\n";
      exit(-1);
    }

    // Optionally connect and wait for the storage nodes (ndbd's)
    if (cluster_connection.wait_until_ready(30,0) < 0)
    {
      std::cout << "Cluster was not ready within 30 secs.\n";
      exit(-1);
    }

    // connect to mysql server
    MYSQL mysql;
    if ( !mysql_init(&mysql) ) {
      std::cout << "mysql_init failed\n";
      exit(-1);
    }
    if ( !mysql_real_connect(&mysql, "localhost", "root", "", "",
        0, mysqld_sock, 0) )
      MYSQLERROR(mysql);

    // run the application code
    run_application(mysql, cluster_connection);
  }

  ndb_end(0);

  return 0;
}

static void create_table(MYSQL &);
static void do_insert(Ndb &);
static void do_update(Ndb &);
static void do_delete(Ndb &);
static void do_read(Ndb &);

static void run_application(MYSQL &mysql,
       Ndb_cluster_connection &cluster_connection)
{
```

```
  /*********************************************
   * Connect to database via mysql-c          *ndb_examples
   *********************************************/
  mysql_query(&mysql, "CREATE DATABASE ndb_examples");
  if (mysql_query(&mysql, "USE ndb_examples") != 0) MYSQLERROR(mysql);
  create_table(mysql);

  /*********************************************
   * Connect to database via NDB API           *
   *********************************************/
  // Object representing the database
  Ndb myNdb( &cluster_connection, "ndb_examples" );
  if (myNdb.init()) APIERROR(myNdb.getNdbError());

  /*
   * Do different operations on database
   */
  do_insert(myNdb);
  do_update(myNdb);
  do_delete(myNdb);
  do_read(myNdb);
}

/*********************************************************
 * Create a table named api_simple if it does not exist *
 *********************************************************/
static void create_table(MYSQL &mysql)
{
  while (mysql_query(&mysql,
    "CREATE TABLE"
    "  api_simple"
    "    (ATTR1 INT UNSIGNED NOT NULL PRIMARY KEY,"
    "     ATTR2 INT UNSIGNED NOT NULL)"
    "  ENGINE=NDB"))
  {
    if (mysql_errno(&mysql) == ER_TABLE_EXISTS_ERROR)
    {
      std::cout << "NDB Cluster already has example table: api_simple. "
      << "Dropping it..." << std::endl;
      mysql_query(&mysql, "DROP TABLE api_simple");
    }
    else MYSQLERROR(mysql);
  }
}

/**************************************************************************
 * Using 5 transactions, insert 10 tuples in table: (0,0),(1,1),...,(9,9) *
 **************************************************************************/
static void do_insert(Ndb &myNdb)
{
  const NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable("api_simple");

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  for (int i = 0; i < 5; i++) {
    NdbTransaction *myTransaction= myNdb.startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

    NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
    if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

    myOperation->insertTuple();
    myOperation->equal("ATTR1", i);
    myOperation->setValue("ATTR2", i);

    myOperation= myTransaction->getNdbOperation(myTable);
    if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

    myOperation->insertTuple();
    myOperation->equal("ATTR1", i+5);
```

```
    myOperation->setValue("ATTR2", i+5);

    if (myTransaction->execute( NdbTransaction::Commit ) == -1)
      APIERROR(myTransaction->getNdbError());

    myNdb.closeTransaction(myTransaction);
  }
}

/*****************************************************************
 * Update the second attribute in half of the tuples (adding 10) *
 *****************************************************************/
static void do_update(Ndb &myNdb)
{
  const NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable("api_simple");

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  for (int i = 0; i < 10; i+=2) {
    NdbTransaction *myTransaction= myNdb.startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

    NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
    if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

    myOperation->updateTuple();
    myOperation->equal( "ATTR1", i );
    myOperation->setValue( "ATTR2", i+10);

    if( myTransaction->execute( NdbTransaction::Commit ) == -1 )
      APIERROR(myTransaction->getNdbError());

    myNdb.closeTransaction(myTransaction);
  }
}

/*************************************************
 * Delete one tuple (the one with primary key 3) *
 *************************************************/
static void do_delete(Ndb &myNdb)
{
  const NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable("api_simple");

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  NdbTransaction *myTransaction= myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
  if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

  myOperation->deleteTuple();
  myOperation->equal( "ATTR1", 3 );

  if (myTransaction->execute(NdbTransaction::Commit) == -1)
    APIERROR(myTransaction->getNdbError());

  myNdb.closeTransaction(myTransaction);
}

/*****************************
 * Read and print all tuples *
 *****************************/
static void do_read(Ndb &myNdb)
{
  const NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable("api_simple");
```

```
  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  std::cout << "ATTR1 ATTR2" << std::endl;

  for (int i = 0; i < 10; i++) {
    NdbTransaction *myTransaction= myNdb.startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

    NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
    if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

    myOperation->readTuple(NdbOperation::LM_Read);
    myOperation->equal("ATTR1", i);

    NdbRecAttr *myRecAttr= myOperation->getValue("ATTR2", NULL);
    if (myRecAttr == NULL) APIERROR(myTransaction->getNdbError());

    if(myTransaction->execute( NdbTransaction::Commit ) == -1)
      APIERROR(myTransaction->getNdbError());

    if (myTransaction->getNdbError().classification == NdbError::NoDataFound)
      if (i == 3)
        std::cout << "Detected that deleted tuple doesn't exist!" << std::endl;
      else
 APIERROR(myTransaction->getNdbError());

    if (i != 3) {
      printf(" %2d    %2d\n", i, myRecAttr->u_32_value());
    }
    myNdb.closeTransaction(myTransaction);
  }
}
```

2.5.2 NDB API Example Using Synchronous Transactions and Multiple Clusters

This example demonstrates synchronous transactions and connecting to multiple clusters in a single NDB API application.

The source code for this program may be found in the NDB Cluster source tree, in the file `storage/ndb/ndbapi-examples/ndbapi_simple_dual/main.cpp`.

Note

The example file was formerly named `ndbapi_simple_dual.cpp`.

```
/*
 *  ndbapi_simple_dual: Using synchronous transactions in NDB API
 *
 *  Correct output from this program is:
 *
 *  ATTR1 ATTR2
 *    0    10
 *    1     1
 *    2    12
 *  Detected that deleted tuple doesn't exist!
 *    4    14
 *    5     5
 *    6    16
 *    7     7
 *    8    18
 *    9     9
 *  ATTR1 ATTR2
 *    0    10
 *    1     1
 *    2    12
 *  Detected that deleted tuple doesn't exist!
 *    4    14
```

```
 *    5     5
 *    6    16
 *    7     7
 *    8    18
 *    9     9
 *
 */

#ifdef _WIN32
#include <winsock2.h>
#endif
#include <mysql.h>
#include <NdbApi.hpp>
#include <stdlib.h>
// Used for cout
#include <stdio.h>
#include <iostream>

static void run_application(MYSQL &, Ndb_cluster_connection &, const char* table, const char* db);

#define PRINT_ERROR(code,msg) \
  std::cout << "Error in " << __FILE__ << ", line: " << __LINE__ \
            << ", code: " << code \
            << ", msg: " << msg << "." << std::endl
#define MYSQLERROR(mysql) { \
  PRINT_ERROR(mysql_errno(&mysql),mysql_error(&mysql)); \
  exit(-1); }
#define APIERROR(error) { \
  PRINT_ERROR(error.code,error.message); \
  exit(-1); }

int main(int argc, char** argv)
{
  if (argc != 5)
  {
    std::cout << "Arguments are <socket mysqld1> <connect_string cluster 1> <socket mysqld2> <connect_strin
    exit(-1);
  }
  // ndb_init must be called first
  ndb_init();
  {
    char * mysqld1_sock  = argv[1];
    const char *connectstring1 = argv[2];
    char * mysqld2_sock = argv[3];
    const char *connectstring2 = argv[4];

    // Object representing the cluster 1
    Ndb_cluster_connection cluster1_connection(connectstring1);
    MYSQL mysql1;
    // Object representing the cluster 2
    Ndb_cluster_connection cluster2_connection(connectstring2);
    MYSQL mysql2;

    // connect to mysql server and cluster 1 and run application
    // Connect to cluster 1  management server (ndb_mgmd)
    if (cluster1_connection.connect(4 /* retries               */,
        5 /* delay between retries */,
        1 /* verbose               */))
    {
      std::cout << "Cluster 1 management server was not ready within 30 secs.\n";
      exit(-1);
    }
    // Optionally connect and wait for the storage nodes (ndbd's)
    if (cluster1_connection.wait_until_ready(30,0) < 0)
    {
      std::cout << "Cluster 1 was not ready within 30 secs.\n";
      exit(-1);
    }
    // connect to mysql server in cluster 1
    if ( !mysql_init(&mysql1) ) {
      std::cout << "mysql_init failed\n";
      exit(-1);
```

```
    }
    if ( !mysql_real_connect(&mysql1, "localhost", "root", "", "",
            0, mysqld1_sock, 0) )
      MYSQLERROR(mysql1);


    // connect to mysql server and cluster 2 and run application

    // Connect to cluster management server (ndb_mgmd)
    if (cluster2_connection.connect(4 /* retries               */,
        5 /* delay between retries */,
        1 /* verbose               */))
    {
      std::cout << "Cluster 2 management server was not ready within 30 secs.\n";
      exit(-1);
    }
    // Optionally connect and wait for the storage nodes (ndbd's)
    if (cluster2_connection.wait_until_ready(30,0) < 0)
    {
      std::cout << "Cluster 2 was not ready within 30 secs.\n";
      exit(-1);
    }
    // connect to mysql server in cluster 2
    if ( !mysql_init(&mysql2) ) {
      std::cout << "mysql_init failed\n";
      exit(-1);
    }
    if ( !mysql_real_connect(&mysql2, "localhost", "root", "", "",
            0, mysqld2_sock, 0) )
      MYSQLERROR(mysql2);

    // run the application code
    run_application(mysql1, cluster1_connection, "api_simple_dual_1", "ndb_examples");
    run_application(mysql2, cluster2_connection, "api_simple_dual_2", "ndb_examples");
  }
  // Note: all connections must have been destroyed before calling ndb_end()
  ndb_end(0);

  return 0;
}

static void create_table(MYSQL &, const char* table);
static void do_insert(Ndb &, const char* table);
static void do_update(Ndb &, const char* table);
static void do_delete(Ndb &, const char* table);
static void do_read(Ndb &, const char* table);
static void drop_table(MYSQL &,const char* table);

static void run_application(MYSQL &mysql,
       Ndb_cluster_connection &cluster_connection,
       const char* table,
       const char* db)
{
  /********************************************
   * Connect to database via mysql-c          *
   ********************************************/
 char db_stmt[256];
 sprintf(db_stmt, "CREATE DATABASE %s\n", db);
  mysql_query(&mysql, db_stmt);
 sprintf(db_stmt, "USE %s", db);
  if (mysql_query(&mysql, db_stmt) != 0) MYSQLERROR(mysql);
  create_table(mysql, table);

  /********************************************
   * Connect to database via NdbApi           *
   ********************************************/
  // Object representing the database
  Ndb myNdb( &cluster_connection, db );
  if (myNdb.init()) APIERROR(myNdb.getNdbError());

  /*
   * Do different operations on database
```

```
   */
  do_insert(myNdb, table);
  do_update(myNdb, table);
  do_delete(myNdb, table);
  do_read(myNdb, table);
  /*
   * Drop the table
   */
  drop_table(mysql,table);
}

/*********************************************************
 * Create a table named by table if it does not exist *
 *********************************************************/
static void create_table(MYSQL &mysql, const char* table)
{
  char create_stmt[256];

  sprintf(create_stmt, "CREATE TABLE %s \
           (ATTR1 INT UNSIGNED NOT NULL PRIMARY KEY,\
            ATTR2 INT UNSIGNED NOT NULL)\
           ENGINE=NDB", table);
  if (mysql_query(&mysql, create_stmt))
    MYSQLERROR(mysql);
}


/**************************************************************************
 * Using 5 transactions, insert 10 tuples in table: (0,0),(1,1),...,(9,9) *
 **************************************************************************/
static void do_insert(Ndb &myNdb, const char* table)
{
  const NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable(table);

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  for (int i = 0; i < 5; i++) {
    NdbTransaction *myTransaction= myNdb.startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

    NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
    if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

    myOperation->insertTuple();
    myOperation->equal("ATTR1", i);
    myOperation->setValue("ATTR2", i);

    myOperation= myTransaction->getNdbOperation(myTable);
    if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

    myOperation->insertTuple();
    myOperation->equal("ATTR1", i+5);
    myOperation->setValue("ATTR2", i+5);

    if (myTransaction->execute( NdbTransaction::Commit ) == -1)
      APIERROR(myTransaction->getNdbError());

    myNdb.closeTransaction(myTransaction);
  }
}

/*****************************************************************
 * Update the second attribute in half of the tuples (adding 10) *
 *****************************************************************/
static void do_update(Ndb &myNdb, const char* table)
{
  const NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable(table);

  if (myTable == NULL)
```

```
    APIERROR(myDict->getNdbError());

  for (int i = 0; i < 10; i+=2) {
    NdbTransaction *myTransaction= myNdb.startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

    NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
    if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

    myOperation->updateTuple();
    myOperation->equal( "ATTR1", i );
    myOperation->setValue( "ATTR2", i+10);

    if( myTransaction->execute( NdbTransaction::Commit ) == -1 )
      APIERROR(myTransaction->getNdbError());

    myNdb.closeTransaction(myTransaction);
  }
}

/*************************************************
 * Delete one tuple (the one with primary key 3) *
 *************************************************/
static void do_delete(Ndb &myNdb, const char* table)
{
  const NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable(table);

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  NdbTransaction *myTransaction= myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
  if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

  myOperation->deleteTuple();
  myOperation->equal( "ATTR1", 3 );

  if (myTransaction->execute(NdbTransaction::Commit) == -1)
    APIERROR(myTransaction->getNdbError());

  myNdb.closeTransaction(myTransaction);
}

/*****************************
 * Read and print all tuples *
 *****************************/
static void do_read(Ndb &myNdb, const char* table)
{
  const NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable(table);

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  std::cout << "ATTR1 ATTR2" << std::endl;

  for (int i = 0; i < 10; i++) {
    NdbTransaction *myTransaction= myNdb.startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

    NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
    if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

    myOperation->readTuple(NdbOperation::LM_Read);
    myOperation->equal("ATTR1", i);

    NdbRecAttr *myRecAttr= myOperation->getValue("ATTR2", NULL);
    if (myRecAttr == NULL) APIERROR(myTransaction->getNdbError());
```

```
    if(myTransaction->execute( NdbTransaction::Commit ) == -1)
    {
      if (i == 3) {
 std::cout << "Detected that deleted tuple doesn't exist!" << std::endl;
      } else {
 APIERROR(myTransaction->getNdbError());
      }
    }

    if (i != 3) {
      printf(" %2d    %2d\n", i, myRecAttr->u_32_value());
    }
    myNdb.closeTransaction(myTransaction);
  }
}

/*************************
 * Drop table after usage *
 *************************/
static void drop_table(MYSQL &mysql, const char* table)
{
  char drop_stmt[75];
  sprintf(drop_stmt, "DROP TABLE %s", table);
  if (mysql_query(&mysql,drop_stmt))
      MYSQLERROR(mysql);
}
```

Prior to NDB 8.0.1, this program could not be run more than once in succession during the same session (Bug #27009386).

2.5.3 NDB API Example: Handling Errors and Retrying Transactions

This program demonstrates handling errors and retrying failed transactions using the NDB API.

The source code for this example can be found in `storage/ndb/ndbapi-examples/ndbapi_retries/ndbapi_retries.cpp` in the NDB Cluster source tree.

There are many ways to program using the NDB API. In this example, we perform two inserts in the same transaction using `NdbTransaction::execute(NoCommit)`.

In NDB API applications, there are two types of failures to be taken into account:

1. **Transaction failures**: If nonpermanent, these can be handled by re-executing the transaction.
2. **Application errors**: These are indicated by `APIERROR`; they must be handled by the application programmer.

```
//
//  ndbapi_retries.cpp: Error handling and transaction retries
//
//  There are many ways to program using the NDB API.  In this example
//  we execute two inserts in the same transaction using
//  NdbConnection::execute(NoCommit).
//
//  Transaction failing is handled by re-executing the transaction
//  in case of non-permanent transaction errors.
//  Application errors (i.e. errors at points marked with APIERROR)
//  should be handled by the application programmer.

#include <mysql.h>
#include <mysqld_error.h>
#include <NdbApi.hpp>

// Used for cout
#include <iostream>

// Used for sleep (use your own version of sleep)
#include <unistd.h>
#define TIME_TO_SLEEP_BETWEEN_TRANSACTION_RETRIES 1
```

```
#define PRINT_ERROR(code,msg) \
  std::cout << "Error in " << __FILE__ << ", line: " << __LINE__ \
            << ", code: " << code \
            << ", msg: " << msg << "." << std::endl
#define MYSQLERROR(mysql) { \
  PRINT_ERROR(mysql_errno(&mysql),mysql_error(&mysql)); \
  exit(-1); }

//
//  APIERROR prints an NdbError object
//
#define APIERROR(error) \
  { std::cout << "API ERROR: " << error.code << " " << error.message \
              << std::endl \
              << "           " << "Status: " << error.status \
              << ", Classification: " << error.classification << std::endl\
              << "           " << "File: " << __FILE__ \
              << " (Line: " << __LINE__ << ")" << std::endl \
              ; \
  }

//
//  TRANSERROR prints all error info regarding an NdbTransaction
//
#define TRANSERROR(ndbTransaction) \
  { NdbError error = ndbTransaction->getNdbError(); \
    std::cout << "TRANS ERROR: " << error.code << " " << error.message \
              << std::endl \
              << "           " << "Status: " << error.status \
              << ", Classification: " << error.classification << std::endl \
              << "           " << "File: " << __FILE__ \
              << " (Line: " << __LINE__ << ")" << std::endl \
              ; \
    printTransactionError(ndbTransaction); \
  }

void printTransactionError(NdbTransaction *ndbTransaction) {
  const NdbOperation *ndbOp = NULL;
  int i=0;

  /****************************************************************
   * Print NdbError object of every operations in the transaction *
   ****************************************************************/
  while ((ndbOp = ndbTransaction->getNextCompletedOperation(ndbOp)) != NULL) {
    NdbError error = ndbOp->getNdbError();
    std::cout << "           OPERATION " << i+1 << ": "
       << error.code << " " << error.message << std::endl
       << "           Status: " << error.status
       << ", Classification: " << error.classification << std::endl;
    i++;
  }
}


//
//  Example insert
//  @param myNdb          Ndb object representing NDB Cluster
//  @param myTransaction  NdbTransaction used for transaction
//  @param myTable        Table to insert into
//  @param error          NdbError object returned in case of errors
//  @return -1 in case of failures, 0 otherwise
//
int insert(int transactionId, NdbTransaction* myTransaction,
    const NdbDictionary::Table *myTable) {
  NdbOperation  *myOperation;          // For other operations

  myOperation = myTransaction->getNdbOperation(myTable);
  if (myOperation == NULL) return -1;

  if (myOperation->insertTuple() ||
      myOperation->equal("ATTR1", transactionId) ||
      myOperation->setValue("ATTR2", transactionId)) {
```

```
    APIERROR(myOperation->getNdbError());
    exit(-1);
  }

  return myTransaction->execute(NdbTransaction::NoCommit);
}


//
//  Execute function which re-executes (tries 10 times) the transaction
//  if there are temporary errors (e.g. the NDB Cluster is overloaded).
//  @return -1 failure, 1 success
//
int executeInsertTransaction(int transactionId, Ndb* myNdb,
        const NdbDictionary::Table *myTable) {
  int result = 0;                       // No result yet
  int noOfRetriesLeft = 10;
  NdbTransaction  *myTransaction;         // For other transactions
  NdbError ndberror;

  while (noOfRetriesLeft > 0 && !result) {

    /*********************************
     * Start and execute transaction *
     *********************************/
    myTransaction = myNdb->startTransaction();
    if (myTransaction == NULL) {
      APIERROR(myNdb->getNdbError());
      ndberror = myNdb->getNdbError();
      result = -1;  // Failure
    } else if (insert(transactionId, myTransaction, myTable) ||
        insert(10000+transactionId, myTransaction, myTable) ||
        myTransaction->execute(NdbTransaction::Commit)) {
      TRANSERROR(myTransaction);
      ndberror = myTransaction->getNdbError();
      result = -1;  // Failure
    } else {
      result = 1;   // Success
    }

    /**********************************
     * If failure, then analyze error *
     **********************************/
    if (result == -1) {
      switch (ndberror.status) {
      case NdbError::Success:
 break;
      case NdbError::TemporaryError:
 std::cout << "Retrying transaction..." << std::endl;
 sleep(TIME_TO_SLEEP_BETWEEN_TRANSACTION_RETRIES);
 --noOfRetriesLeft;
 result = 0;   // No completed transaction yet
 break;

      case NdbError::UnknownResult:
      case NdbError::PermanentError:
 std::cout << "No retry of transaction..." << std::endl;
 result = -1;  // Permanent failure
 break;
      }
    }

    /*********************
     * Close transaction *
     *********************/
    if (myTransaction != NULL) {
      myNdb->closeTransaction(myTransaction);
    }
  }

  if (result != 1) exit(-1);
  return result;
```

```
}

/*********************************************************
 * Create a table named api_retries if it does not exist *
 *********************************************************/
static void create_table(MYSQL &mysql)
{
  while(mysql_query(&mysql,
    "CREATE TABLE "
    "  api_retries"
    "    (ATTR1 INT UNSIGNED NOT NULL PRIMARY KEY,"
    "     ATTR2 INT UNSIGNED NOT NULL)"
    "  ENGINE=NDB"))
  {
    if (mysql_errno(&mysql) == ER_TABLE_EXISTS_ERROR)
    {
      std::cout << "NDB Cluster already has example table: api_scan. "
      << "Dropping it..." << std::endl;
        mysql_query(&mysql, "DROP TABLE api_retries");
    }
    else MYSQLERROR(mysql);
  }
}


int main(int argc, char** argv)
{
  if (argc != 3)
  {
    std::cout << "Arguments are <socket mysqld> <connect_string cluster>.\n";
    exit(-1);
  }
  char * mysqld_sock  = argv[1];
  const char *connection_string = argv[2];
  ndb_init();

  Ndb_cluster_connection *cluster_connection=
    new Ndb_cluster_connection(connection_string); // Object representing the cluster

  int r= cluster_connection->connect(5 /* retries               */,
         3 /* delay between retries */,
         1 /* verbose               */);
  if (r > 0)
  {
    std::cout
      << "Cluster connect failed, possibly resolved with more retries.\n";
    exit(-1);
  }
  else if (r < 0)
  {
    std::cout
      << "Cluster connect failed.\n";
    exit(-1);
  }

  if (cluster_connection->wait_until_ready(30,30))
  {
    std::cout << "Cluster was not ready within 30 secs." << std::endl;
    exit(-1);
  }
  // connect to mysql server
  MYSQL mysql;
  if ( !mysql_init(&mysql) ) {
    std::cout << "mysql_init failed\n";
    exit(-1);
  }
  if ( !mysql_real_connect(&mysql, "localhost", "root", "", "",
      0, mysqld_sock, 0) )
    MYSQLERROR(mysql);

  /********************************************
   * Connect to database via mysql-c          *
```

```
 ********************************************/
mysql_query(&mysql, "CREATE DATABASE ndb_examples");
if (mysql_query(&mysql, "USE ndb_examples") != 0) MYSQLERROR(mysql);
create_table(mysql);

Ndb* myNdb= new Ndb( cluster_connection,
       "ndb_examples" );  // Object representing the database

if (myNdb->init() == -1) {
  APIERROR(myNdb->getNdbError());
  exit(-1);
}

const NdbDictionary::Dictionary* myDict= myNdb->getDictionary();
const NdbDictionary::Table *myTable= myDict->getTable("api_retries");
if (myTable == NULL)
{
  APIERROR(myDict->getNdbError());
  return -1;
}
/************************************
 * Execute some insert transactions *
 ************************************/

std::cout << "Ready to insert rows.  You will see notices for temporary "
  "errors, permenant errors, and retries. \n";
for (int i = 10000; i < 20000; i++) {
  executeInsertTransaction(i, myNdb, myTable);
}
std::cout << "Done.\n";

delete myNdb;
delete cluster_connection;

ndb_end(0);
return 0;
}
```

2.5.4 NDB API Basic Scanning Example

This example illustrates how to use the NDB scanning API. It shows how to perform a scan, how to scan for an update, and how to scan for a delete, making use of the `NdbScanFilter` and `NdbScanOperation` classes.

The source code for this example may found in the NDB Cluster source tree, in the file `storage/ndb/ndbapi-examples/ndbapi_scan/ndbapi_scan.cpp`.

This example makes use of the following classes and methods:

- `Ndb_cluster_connection`:
  - `connect()`
  - `wait_until_ready()`
- `Ndb`:
  - `init()`
  - `getDictionary()`
  - `startTransaction()`
  - `closeTransaction()`
- `NdbTransaction`:
  - `getNdbScanOperation()`

  - `execute()`
- `NdbOperation`:
  - `insertTuple()`
  - `equal()`
  - `getValue()`
  - `setValue()`
- `NdbScanOperation`:
  - `readTuples()`
  - `nextResult()`
  - `deleteCurrentTuple()`
  - `updateCurrentTuple()`
- `NdbDictionary`:
  - `Dictionary::getTable()`
  - `Table::getColumn()`
  - `Column::getLength()`
- `NdbScanFilter`:
  - `begin()`
  - `eq()`
  - `end()`

```
/*
   Copyright (c) 2005, 2017, Oracle and/or its affiliates. All rights reserved.

   This program is free software; you can redistribute it and/or modify
   it under the terms of the GNU General Public License as published by
   the Free Software Foundation; version 2 of the License.

   This program is distributed in the hope that it will be useful,
   but WITHOUT ANY WARRANTY; without even the implied warranty of
   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
   GNU General Public License for more details.

   You should have received a copy of the GNU General Public License
   along with this program; if not, write to the Free Software
   Foundation, Inc., 51 Franklin St, Fifth Floor, Boston, MA 02110-1301  USA
*/


/*
 * ndbapi_scan.cpp:
 * Illustrates how to use the scan api in the NDBAPI.
 * The example shows how to do scan, scan for update and scan for delete
 * using NdbScanFilter and NdbScanOperation
 *
 * Classes and methods used in this example:
 *
 *  Ndb_cluster_connection
 *       connect()
 *       wait_until_ready()
```

```
 *
 *  Ndb
 *       init()
 *       getDictionary()
 *       startTransaction()
 *       closeTransaction()
 *
 *  NdbTransaction
 *       getNdbScanOperation()
 *       execute()
 *
 *  NdbScanOperation
 *       getValue()
 *       readTuples()
 *       nextResult()
 *       deleteCurrentTuple()
 *       updateCurrentTuple()
 *
 *  const NdbDictionary::Dictionary
 *       getTable()
 *
 *  const NdbDictionary::Table
 *       getColumn()
 *
 *  const NdbDictionary::Column
 *       getLength()
 *
 *  NdbOperation
 *       insertTuple()
 *       equal()
 *       setValue()
 *
 *  NdbScanFilter
 *       begin()
 *  eq()
 *  end()
 *
 */

#ifdef _WIN32
#include <winsock2.h>
#endif
#include <mysql.h>
#include <mysqld_error.h>
#include <NdbApi.hpp>
// Used for cout
#include <iostream>
#include <stdio.h>
#include <string.h>
#include <stdlib.h>
#include <config.h>
#ifdef HAVE_SYS_SELECT_H
#include <sys/select.h>
#endif

/**
 * Helper sleep function
 */
static void
milliSleep(int milliseconds){
  struct timeval sleeptime;
  sleeptime.tv_sec = milliseconds / 1000;
  sleeptime.tv_usec = (milliseconds - (sleeptime.tv_sec * 1000)) * 1000000;
  select(0, 0, 0, 0, &sleeptime);
}


/**
 * Helper debugging macros
 */
#define PRINT_ERROR(code,msg) \
  std::cout << "Error in " << __FILE__ << ", line: " << __LINE__ \
```

```
            << ", code: " << code \
            << ", msg: " << msg << "." << std::endl
#define MYSQLERROR(mysql) { \
  PRINT_ERROR(mysql_errno(&mysql),mysql_error(&mysql)); \
  exit(-1); }
#define APIERROR(error) { \
  PRINT_ERROR(error.code,error.message); \
  exit(-1); }

struct Car
{
  /**
   * Note memset, so that entire char-fields are cleared
   *   as all 20 bytes are significant (as type is char)
   */
  Car() { memset(this, 0, sizeof(* this)); }

  unsigned int reg_no;
  char brand[20];
  char color[20];
};

/**
 * Function to drop table
 */
void drop_table(MYSQL &mysql)
{
  if (mysql_query(&mysql, "DROP TABLE IF EXISTS api_scan"))
    MYSQLERROR(mysql);
}


/**
 * Function to create table
 */
void create_table(MYSQL &mysql)
{
  while (mysql_query(&mysql,
    "CREATE TABLE"
    "  api_scan"
    "    (REG_NO INT UNSIGNED NOT NULL,"
    "     BRAND CHAR(20) NOT NULL,"
    "     COLOR CHAR(20) NOT NULL,"
    "     PRIMARY KEY USING HASH (REG_NO))"
    "  ENGINE=NDB"))
  {
    if (mysql_errno(&mysql) != ER_TABLE_EXISTS_ERROR)
      MYSQLERROR(mysql);
    std::cout << "NDB Cluster already has example table: api_scan. "
       << "Dropping it..." << std::endl;
    drop_table(mysql);
  }
}

int populate(Ndb * myNdb)
{
  int i;
  Car cars[15];

  const NdbDictionary::Dictionary* myDict= myNdb->getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable("api_scan");

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  /**
   * Five blue mercedes
   */
  for (i = 0; i < 5; i++)
  {
    cars[i].reg_no = i;
    sprintf(cars[i].brand, "Mercedes");
```

```
    sprintf(cars[i].color, "Blue");
  }

  /**
   * Five black bmw
   */
  for (i = 5; i < 10; i++)
  {
    cars[i].reg_no = i;
    sprintf(cars[i].brand, "BMW");
    sprintf(cars[i].color, "Black");
  }

  /**
   * Five pink toyotas
   */
  for (i = 10; i < 15; i++)
  {
    cars[i].reg_no = i;
    sprintf(cars[i].brand, "Toyota");
    sprintf(cars[i].color, "Pink");
  }

  NdbTransaction* myTrans = myNdb->startTransaction();
  if (myTrans == NULL)
    APIERROR(myNdb->getNdbError());

  for (i = 0; i < 15; i++)
  {
    NdbOperation* myNdbOperation = myTrans->getNdbOperation(myTable);
    if (myNdbOperation == NULL)
      APIERROR(myTrans->getNdbError());
    myNdbOperation->insertTuple();
    myNdbOperation->equal("REG_NO", cars[i].reg_no);
    myNdbOperation->setValue("BRAND", cars[i].brand);
    myNdbOperation->setValue("COLOR", cars[i].color);
  }

  int check = myTrans->execute(NdbTransaction::Commit);

  myTrans->close();

  return check != -1;
}

int scan_delete(Ndb* myNdb,
  int column,
  const char * color)

{

  // Scan all records exclusive and delete
  // them one by one
  int                  retryAttempt = 0;
  const int            retryMax = 10;
  int deletedRows = 0;
  int check;
  NdbError              err;
  NdbTransaction *myTrans;
  NdbScanOperation *myScanOp;

  const NdbDictionary::Dictionary* myDict= myNdb->getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable("api_scan");

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  /**
   * Loop as long as :
   *  retryMax not reached
   *  failed operations due to TEMPORARY erros
   *
```

```
   * Exit loop;
   *  retyrMax reached
   *  Permanent error (return -1)
   */
  while (true)
  {
    if (retryAttempt >= retryMax)
    {
      std::cout << "ERROR: has retried this operation " << retryAttempt
  << " times, failing!" << std::endl;
      return -1;
    }

    myTrans = myNdb->startTransaction();
    if (myTrans == NULL)
    {
      const NdbError err = myNdb->getNdbError();

      if (err.status == NdbError::TemporaryError)
      {
milliSleep(50);
retryAttempt++;
continue;
      }
      std::cout <<  err.message << std::endl;
      return -1;
    }

   /**
    * Get a scan operation.
    */
    myScanOp = myTrans->getNdbScanOperation(myTable);
    if (myScanOp == NULL)
    {
      std::cout << myTrans->getNdbError().message << std::endl;
      myNdb->closeTransaction(myTrans);
      return -1;
    }

    /**
     * Define a result set for the scan.
     */
    if(myScanOp->readTuples(NdbOperation::LM_Exclusive) != 0)
    {
      std::cout << myTrans->getNdbError().message << std::endl;
      myNdb->closeTransaction(myTrans);
      return -1;
    }

    /**
     * Use NdbScanFilter to define a search critera
     */
    NdbScanFilter filter(myScanOp) ;
    if(filter.begin(NdbScanFilter::AND) < 0  ||
       filter.cmp(NdbScanFilter::COND_EQ, column, color, 20) < 0 ||
       filter.end() < 0)
    {
      std::cout <<  myTrans->getNdbError().message << std::endl;
      myNdb->closeTransaction(myTrans);
      return -1;
    }

    /**
     * Start scan    (NoCommit since we are only reading at this stage);
     */
    if(myTrans->execute(NdbTransaction::NoCommit) != 0){
      err = myTrans->getNdbError();
      if(err.status == NdbError::TemporaryError){
std::cout << myTrans->getNdbError().message << std::endl;
myNdb->closeTransaction(myTrans);
milliSleep(50);
continue;
```

```
      }
      std::cout << err.code << std::endl;
      std::cout << myTrans->getNdbError().code << std::endl;
      myNdb->closeTransaction(myTrans);
      return -1;
    }


   /**
    * start of loop: nextResult(true) means that "parallelism" number of
    * rows are fetched from NDB and cached in NDBAPI
    */
    while((check = myScanOp->nextResult(true)) == 0){
      do
      {
if (myScanOp->deleteCurrentTuple() != 0)
{
  std::cout << myTrans->getNdbError().message << std::endl;
  myNdb->closeTransaction(myTrans);
  return -1;
}
deletedRows++;

/**
 * nextResult(false) means that the records
 * cached in the NDBAPI are modified before
 * fetching more rows from NDB.
 */
      } while((check = myScanOp->nextResult(false)) == 0);

      /**
       * NoCommit when all cached tuple have been marked for deletion
       */
      if(check != -1)
      {
check = myTrans->execute(NdbTransaction::NoCommit);
      }

      /**
       * Check for errors
       */
      err = myTrans->getNdbError();
      if(check == -1)
      {
if(err.status == NdbError::TemporaryError)
{
  std::cout << myTrans->getNdbError().message << std::endl;
  myNdb->closeTransaction(myTrans);
  milliSleep(50);
  continue;
}
      }
      /**
       * End of loop
       */
    }
    /**
     * Commit all prepared operations
     */
    if(myTrans->execute(NdbTransaction::Commit) == -1)
    {
      if(err.status == NdbError::TemporaryError){
std::cout << myTrans->getNdbError().message << std::endl;
myNdb->closeTransaction(myTrans);
milliSleep(50);
continue;
      }
    }

    std::cout << myTrans->getNdbError().message << std::endl;
    myNdb->closeTransaction(myTrans);
    return 0;
```

```
  }

  if(myTrans!=0)
  {
    std::cout << myTrans->getNdbError().message << std::endl;
    myNdb->closeTransaction(myTrans);
  }
  return -1;
}


int scan_update(Ndb* myNdb,
  int update_column,
  const char * before_color,
  const char * after_color)

{

  // Scan all records exclusive and update
  // them one by one
  int                  retryAttempt = 0;
  const int            retryMax = 10;
  int updatedRows = 0;
  int check;
  NdbError              err;
  NdbTransaction *myTrans;
  NdbScanOperation *myScanOp;

  const NdbDictionary::Dictionary* myDict= myNdb->getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable("api_scan");

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  /**
   * Loop as long as :
   *  retryMax not reached
   *  failed operations due to TEMPORARY erros
   *
   * Exit loop;
   *  retryMax reached
   *  Permanent error (return -1)
   */
  while (true)
  {

    if (retryAttempt >= retryMax)
    {
      std::cout << "ERROR: has retried this operation " << retryAttempt
  << " times, failing!" << std::endl;
      return -1;
    }

    myTrans = myNdb->startTransaction();
    if (myTrans == NULL)
    {
      const NdbError err = myNdb->getNdbError();

      if (err.status == NdbError::TemporaryError)
      {
 milliSleep(50);
 retryAttempt++;
 continue;
      }
      std::cout <<  err.message << std::endl;
      return -1;
    }

   /**
    * Get a scan operation.
    */
    myScanOp = myTrans->getNdbScanOperation(myTable);
```

```
    if (myScanOp == NULL)
    {
      std::cout << myTrans->getNdbError().message << std::endl;
      myNdb->closeTransaction(myTrans);
      return -1;
    }

    /**
     * Define a result set for the scan.
     */
    if( myScanOp->readTuples(NdbOperation::LM_Exclusive) )
    {
      std::cout << myTrans->getNdbError().message << std::endl;
      myNdb->closeTransaction(myTrans);
      return -1;
    }

    /**
     * Use NdbScanFilter to define a search critera
     */
    NdbScanFilter filter(myScanOp) ;
    if(filter.begin(NdbScanFilter::AND) < 0  ||
       filter.cmp(NdbScanFilter::COND_EQ, update_column, before_color, 20) <0||
       filter.end() <0)
    {
      std::cout <<  myTrans->getNdbError().message << std::endl;
      myNdb->closeTransaction(myTrans);
      return -1;
    }

    /**
     * Start scan    (NoCommit since we are only reading at this stage);
     */
    if(myTrans->execute(NdbTransaction::NoCommit) != 0)
    {
      err = myTrans->getNdbError();
      if(err.status == NdbError::TemporaryError){
std::cout << myTrans->getNdbError().message << std::endl;
myNdb->closeTransaction(myTrans);
milliSleep(50);
continue;
      }
      std::cout << myTrans->getNdbError().code << std::endl;
      myNdb->closeTransaction(myTrans);
      return -1;
    }

    /**
     * start of loop: nextResult(true) means that "parallelism" number of
     * rows are fetched from NDB and cached in NDBAPI
     */
    while((check = myScanOp->nextResult(true)) == 0){
      do {
/**
 * Get update operation
 */
NdbOperation * myUpdateOp = myScanOp->updateCurrentTuple();
if (myUpdateOp == 0)
{
  std::cout << myTrans->getNdbError().message << std::endl;
  myNdb->closeTransaction(myTrans);
  return -1;
}
updatedRows++;

/**
 * do the update
 */
myUpdateOp->setValue(update_column, after_color);
/**
 * nextResult(false) means that the records
 * cached in the NDBAPI are modified before
```

```
  * fetching more rows from NDB.
  */
      } while((check = myScanOp->nextResult(false)) == 0);

      /**
       * NoCommit when all cached tuple have been updated
       */
      if(check != -1)
      {
 check = myTrans->execute(NdbTransaction::NoCommit);
      }

      /**
       * Check for errors
       */
      err = myTrans->getNdbError();
      if(check == -1)
      {
 if(err.status == NdbError::TemporaryError){
   std::cout << myTrans->getNdbError().message << std::endl;
   myNdb->closeTransaction(myTrans);
   milliSleep(50);
   continue;
 }
      }
      /**
       * End of loop
       */
    }

    /**
     * Commit all prepared operations
     */
    if(myTrans->execute(NdbTransaction::Commit) == -1)
    {
      if(err.status == NdbError::TemporaryError){
 std::cout << myTrans->getNdbError().message << std::endl;
 myNdb->closeTransaction(myTrans);
 milliSleep(50);
 continue;
      }
    }

    std::cout << myTrans->getNdbError().message << std::endl;
    myNdb->closeTransaction(myTrans);
    return 0;
  }


  if(myTrans!=0)
  {
    std::cout << myTrans->getNdbError().message << std::endl;
    myNdb->closeTransaction(myTrans);
  }
  return -1;
}



int scan_print(Ndb * myNdb)
{
// Scan all records exclusive and update
  // them one by one
  int                  retryAttempt = 0;
  const int            retryMax = 10;
  int fetchedRows = 0;
  int check;
  NdbError              err;
  NdbTransaction *myTrans;
  NdbScanOperation *myScanOp;
  /* Result of reading attribute value, three columns:
     REG_NO, BRAND, and COLOR
```

```
  */
 NdbRecAttr *     myRecAttr[3];

 const NdbDictionary::Dictionary* myDict= myNdb->getDictionary();
 const NdbDictionary::Table *myTable= myDict->getTable("api_scan");

 if (myTable == NULL)
   APIERROR(myDict->getNdbError());

 /**
  * Loop as long as :
  *  retryMax not reached
  *  failed operations due to TEMPORARY erros
  *
  * Exit loop;
  *  retyrMax reached
  *  Permanent error (return -1)
  */
 while (true)
 {

   if (retryAttempt >= retryMax)
   {
     std::cout << "ERROR: has retried this operation " << retryAttempt
 << " times, failing!" << std::endl;
     return -1;
   }

   myTrans = myNdb->startTransaction();
   if (myTrans == NULL)
   {
     const NdbError err = myNdb->getNdbError();

     if (err.status == NdbError::TemporaryError)
     {
milliSleep(50);
retryAttempt++;
continue;
     }
    std::cout << err.message << std::endl;
     return -1;
   }
   /*
    * Define a scan operation.
    * NDBAPI.
    */
   myScanOp = myTrans->getNdbScanOperation(myTable);
   if (myScanOp == NULL)
   {
     std::cout << myTrans->getNdbError().message << std::endl;
     myNdb->closeTransaction(myTrans);
     return -1;
   }

   /**
    * Read without locks, without being placed in lock queue
    */
   if( myScanOp->readTuples(NdbOperation::LM_CommittedRead) == -1)
   {
     std::cout << myTrans->getNdbError().message << std::endl;
     myNdb->closeTransaction(myTrans);
     return -1;
   }

   /**
    * Define storage for fetched attributes.
    * E.g., the resulting attributes of executing
    * myOp->getValue("REG_NO") is placed in myRecAttr[0].
    * No data exists in myRecAttr until transaction has commited!
    */
   myRecAttr[0] = myScanOp->getValue("REG_NO");
   myRecAttr[1] = myScanOp->getValue("BRAND");
```

```
    myRecAttr[2] = myScanOp->getValue("COLOR");
    if(myRecAttr[0] ==NULL || myRecAttr[1] == NULL || myRecAttr[2]==NULL)
    {
 std::cout << myTrans->getNdbError().message << std::endl;
 myNdb->closeTransaction(myTrans);
 return -1;
    }
    /**
     * Start scan   (NoCommit since we are only reading at this stage);
     */
    if(myTrans->execute(NdbTransaction::NoCommit) != 0){
      err = myTrans->getNdbError();
      if(err.status == NdbError::TemporaryError){
 std::cout << myTrans->getNdbError().message << std::endl;
 myNdb->closeTransaction(myTrans);
 milliSleep(50);
 continue;
      }
      std::cout << err.code << std::endl;
      std::cout << myTrans->getNdbError().code << std::endl;
      myNdb->closeTransaction(myTrans);
      return -1;
    }

    /**
     * start of loop: nextResult(true) means that "parallelism" number of
     * rows are fetched from NDB and cached in NDBAPI
     */
    while((check = myScanOp->nextResult(true)) == 0){
      do {

 fetchedRows++;
 /**
  * print  REG_NO unsigned int
  */
 std::cout << myRecAttr[0]->u_32_value() << "\t";

 /**
  * print  BRAND character string
  */
 std::cout << myRecAttr[1]->aRef() << "\t";

 /**
  * print  COLOR character string
  */
 std::cout << myRecAttr[2]->aRef() << std::endl;

 /**
  * nextResult(false) means that the records
  * cached in the NDBAPI are modified before
  * fetching more rows from NDB.
  */
      } while((check = myScanOp->nextResult(false)) == 0);

    }
    myNdb->closeTransaction(myTrans);
    return 1;
  }
  return -1;

}

void mysql_connect_and_create(MYSQL & mysql, const char *socket)
{
  bool ok;

  ok = mysql_real_connect(&mysql, "localhost", "root", "", "", 0, socket, 0);
  if(ok) {
    mysql_query(&mysql, "CREATE DATABASE ndb_examples");
    ok = ! mysql_select_db(&mysql, "ndb_examples");
  }
  if(ok) {
```

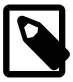
```
    create_table(mysql);
  }

  if(! ok) MYSQLERROR(mysql);
}

void ndb_run_scan(const char * connectstring)
{

  /**************************************************************
   * Connect to ndb cluster                                     *
   **************************************************************/

  Ndb_cluster_connection cluster_connection(connectstring);
  if (cluster_connection.connect(4, 5, 1))
  {
    std::cout << "Unable to connect to cluster within 30 secs." << std::endl;
    exit(-1);
  }
  // Optionally connect and wait for the storage nodes (ndbd's)
  if (cluster_connection.wait_until_ready(30,0) < 0)
  {
    std::cout << "Cluster was not ready within 30 secs.\n";
    exit(-1);
  }

  Ndb myNdb(&cluster_connection,"ndb_examples");
  if (myNdb.init(1024) == -1) {      // Set max 1024  parallel transactions
    APIERROR(myNdb.getNdbError());
    exit(-1);
  }

  /*******************************************
   * Check table definition                  *
   *******************************************/
  int column_color;
  {
    const NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
    const NdbDictionary::Table *t= myDict->getTable("api_scan");
    if(t == NULL)
    {
      std::cout << "Dictionary::getTable() failed.";
      exit(-1);
    }
    Car car;
    if (t->getColumn("COLOR")->getLength() != sizeof(car.color) ||
 t->getColumn("BRAND")->getLength() != sizeof(car.brand))
    {
      std::cout << "Wrong table definition" << std::endl;
      exit(-1);
    }
    column_color= t->getColumn("COLOR")->getColumnNo();
  }

  if(populate(&myNdb) > 0)
    std::cout << "populate: Success!" << std::endl;

  if(scan_print(&myNdb) > 0)
    std::cout << "scan_print: Success!" << std::endl  << std::endl;

  std::cout << "Going to delete all pink cars!" << std::endl;

  {
    /**
     * Note! color needs to be of exact the same size as column defined
     */
    Car tmp;
    sprintf(tmp.color, "Pink");
    if(scan_delete(&myNdb, column_color, tmp.color) > 0)
      std::cout << "scan_delete: Success!" << std::endl  << std::endl;
  }
```

```
  if(scan_print(&myNdb) > 0)
    std::cout << "scan_print: Success!" << std::endl  << std::endl;

  {
    /**
     * Note! color1 & 2 need to be of exact the same size as column defined
     */
    Car tmp1, tmp2;
    sprintf(tmp1.color, "Blue");
    sprintf(tmp2.color, "Black");
    std::cout << "Going to update all " << tmp1.color
       << " cars to " << tmp2.color << " cars!" << std::endl;
    if(scan_update(&myNdb, column_color, tmp1.color, tmp2.color) > 0)
      std::cout << "scan_update: Success!" << std::endl  << std::endl;
  }
  if(scan_print(&myNdb) > 0)
    std::cout << "scan_print: Success!" << std::endl  << std::endl;
}

int main(int argc, char** argv)
{
  if (argc != 3)
  {
    std::cout << "Arguments are <socket mysqld> <connect_string cluster>.\n";
    exit(-1);
  }
  char * mysqld_sock  = argv[1];
  const char *connectstring = argv[2];
  MYSQL mysql;

  mysql_init(& mysql);
  mysql_connect_and_create(mysql, mysqld_sock);

  ndb_init();
  ndb_run_scan(connectstring);
  ndb_end(0);

  mysql_close(&mysql);

  return 0;
}
```

2.5.5 NDB API Example: Using Secondary Indexes in Scans

This program illustrates how to use secondary indexes in the NDB API.

The source code for this example may be found in the NDB Cluster source tree, in `storage/ndb/ndbapi-examples/ndbapi_simple_index/main.cpp`.



Note

This file was previously named `ndbapi_simple_index.cpp`.

The correct output from this program is shown here:

```
ATTR1 ATTR2
0      10
1       1
2      12
Detected that deleted tuple doesn't exist!
4      14
5       5
6      16
7       7
8      18
9       9
```

The listing for this program is shown here:

```
#include <mysql.h>
```

```
#include <mysqld_error.h>
#include <NdbApi.hpp>

// Used for cout
#include <stdio.h>
#include <iostream>

#define PRINT_ERROR(code,msg) \
  std::cout << "Error in " << __FILE__ << ", line: " << __LINE__ \
            << ", code: " << code \
            << ", msg: " << msg << "." << std::endl
#define MYSQLERROR(mysql) { \
  PRINT_ERROR(mysql_errno(&mysql),mysql_error(&mysql)); \
  exit(-1); }
#define APIERROR(error) { \
  PRINT_ERROR(error.code,error.message); \
  exit(-1); }

int main(int argc, char** argv)
{
  if (argc != 3)
    {
    std::cout << "Arguments are <socket mysqld> <connect_string cluster>.\n";
    exit(-1);
  }
  char * mysqld_sock  = argv[1];
  const char *connection_string = argv[2];
  ndb_init();
  MYSQL mysql;

  /**************************************************************
   * Connect to mysql server and create table                   *
   **************************************************************/
  {
    if ( !mysql_init(&mysql) ) {
      std::cout << "mysql_init failed\n";
      exit(-1);
    }
    if ( !mysql_real_connect(&mysql, "localhost", "root", "", "",
        0, mysqld_sock, 0) )
      MYSQLERROR(mysql);

    mysql_query(&mysql, "CREATE DATABASE ndb_examples_1");
    if (mysql_query(&mysql, "USE ndb_examples") != 0) MYSQLERROR(mysql);

    while (mysql_query(&mysql,
      "CREATE TABLE"
      "  api_simple_index"
      "    (ATTR1 INT UNSIGNED,"
      "     ATTR2 INT UNSIGNED NOT NULL,"
      "     PRIMARY KEY USING HASH (ATTR1),"
      "     UNIQUE MYINDEXNAME USING HASH (ATTR2))"
      "  ENGINE=NDB"))
    {
      if (mysql_errno(&mysql) == ER_TABLE_EXISTS_ERROR)
      {
        std::cout << "NDB Cluster already has example table: api_scan. "
        << "Dropping it..." << std::endl;
        mysql_query(&mysql, "DROP TABLE api_simple_index");
      }
      else MYSQLERROR(mysql);
    }
  }

  /**************************************************************
   * Connect to ndb cluster                                     *
   **************************************************************/

  Ndb_cluster_connection *cluster_connection=
    new Ndb_cluster_connection(connection_string); // Object representing the cluster

  if (cluster_connection->connect(5,3,1))
```

```
{
  std::cout << "Connect to cluster management server failed.\n";
  exit(-1);
}

if (cluster_connection->wait_until_ready(30,30))
{
  std::cout << "Cluster was not ready within 30 secs.\n";
  exit(-1);
}

Ndb* myNdb = new Ndb( cluster_connection,
 "ndb_examples" );  // Object representing the database
if (myNdb->init() == -1) {
  APIERROR(myNdb->getNdbError());
  exit(-1);
}

const NdbDictionary::Dictionary* myDict= myNdb->getDictionary();
const NdbDictionary::Table *myTable= myDict->getTable("api_simple_index");
if (myTable == NULL)
  APIERROR(myDict->getNdbError());
const NdbDictionary::Index *myIndex= myDict->getIndex("MYINDEXNAME$unique","api_simple_index");
if (myIndex == NULL)
  APIERROR(myDict->getNdbError());

/**************************************************************************
 * Using 5 transactions, insert 10 tuples in table: (0,0),(1,1),...,(9,9) *
 **************************************************************************/
for (int i = 0; i < 5; i++) {
  NdbTransaction *myTransaction= myNdb->startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb->getNdbError());

  NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
  if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

  myOperation->insertTuple();
  myOperation->equal("ATTR1", i);
  myOperation->setValue("ATTR2", i);

  myOperation = myTransaction->getNdbOperation(myTable);
  if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

  myOperation->insertTuple();
  myOperation->equal("ATTR1", i+5);
  myOperation->setValue("ATTR2", i+5);

  if (myTransaction->execute( NdbTransaction::Commit ) == -1)
    APIERROR(myTransaction->getNdbError());

  myNdb->closeTransaction(myTransaction);
}

/*****************************************
 * Read and print all tuples using index *
 *****************************************/
std::cout << "ATTR1 ATTR2" << std::endl;

for (int i = 0; i < 10; i++) {
  NdbTransaction *myTransaction= myNdb->startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb->getNdbError());

  NdbIndexOperation *myIndexOperation=
    myTransaction->getNdbIndexOperation(myIndex);
  if (myIndexOperation == NULL) APIERROR(myTransaction->getNdbError());

  myIndexOperation->readTuple(NdbOperation::LM_Read);
  myIndexOperation->equal("ATTR2", i);

  NdbRecAttr *myRecAttr= myIndexOperation->getValue("ATTR1", NULL);
  if (myRecAttr == NULL) APIERROR(myTransaction->getNdbError());
```

```
    if(myTransaction->execute( NdbTransaction::Commit,
                               NdbOperation::AbortOnError ) != -1)
      printf(" %2d    %2d\n", myRecAttr->u_32_value(), i);

    myNdb->closeTransaction(myTransaction);
  }

  /*****************************************************************
   * Update the second attribute in half of the tuples (adding 10) *
   *****************************************************************/
  for (int i = 0; i < 10; i+=2) {
    NdbTransaction *myTransaction= myNdb->startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb->getNdbError());

    NdbIndexOperation *myIndexOperation=
      myTransaction->getNdbIndexOperation(myIndex);
    if (myIndexOperation == NULL) APIERROR(myTransaction->getNdbError());

    myIndexOperation->updateTuple();
    myIndexOperation->equal( "ATTR2", i );
    myIndexOperation->setValue( "ATTR2", i+10);

    if( myTransaction->execute( NdbTransaction::Commit ) == -1 )
      APIERROR(myTransaction->getNdbError());

    myNdb->closeTransaction(myTransaction);
  }

  /*************************************************
   * Delete one tuple (the one with primary key 3) *
   *************************************************/
  {
    NdbTransaction *myTransaction= myNdb->startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb->getNdbError());

    NdbIndexOperation *myIndexOperation=
      myTransaction->getNdbIndexOperation(myIndex);
    if (myIndexOperation == NULL) APIERROR(myTransaction->getNdbError());

    myIndexOperation->deleteTuple();
    myIndexOperation->equal( "ATTR2", 3 );

    if (myTransaction->execute(NdbTransaction::Commit) == -1)
      APIERROR(myTransaction->getNdbError());

    myNdb->closeTransaction(myTransaction);
  }

  /*****************************
   * Read and print all tuples *
   *****************************/
  {
    std::cout << "ATTR1 ATTR2" << std::endl;

    for (int i = 0; i < 10; i++) {
      NdbTransaction *myTransaction= myNdb->startTransaction();
      if (myTransaction == NULL) APIERROR(myNdb->getNdbError());

      NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
      if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

      myOperation->readTuple(NdbOperation::LM_Read);
      myOperation->equal("ATTR1", i);

      NdbRecAttr *myRecAttr= myOperation->getValue("ATTR2", NULL);
      if (myRecAttr == NULL) APIERROR(myTransaction->getNdbError());

      if(myTransaction->execute( NdbTransaction::Commit,
                                 NdbOperation::AbortOnError ) == -1)
 if (i == 3) {
   std::cout << "Detected that deleted tuple doesn't exist!\n";
 } else {
```

```
  APIERROR(myTransaction->getNdbError());
 }

      if (i != 3) {
 printf(" %2d    %2d\n", i, myRecAttr->u_32_value());
      }
      myNdb->closeTransaction(myTransaction);
    }
  }

  delete myNdb;
  delete cluster_connection;

  ndb_end(0);
  return 0;
}
```

2.5.6 NDB API Example: Using NdbRecord with Hash Indexes

This program illustrates how to use secondary indexes in the NDB API with the aid of the `NdbRecord` interface.

The source code for this example may be found in the NDB Cluster source trees, in the file `storage/ndb/ndbapi-examples/ndbapi_s_i_ndbrecord/main.cpp`.

When run on a cluster having 2 data nodes, the correct output from this program is as shown here:

```
ATTR1 ATTR2
  0     0   (frag=0)
  1     1   (frag=1)
  2     2   (frag=1)
  3     3   (frag=0)
  4     4   (frag=1)
  5     5   (frag=1)
  6     6   (frag=0)
  7     7   (frag=0)
  8     8   (frag=1)
  9     9   (frag=0)
ATTR1 ATTR2
  0    10
  1     1
  2    12
Detected that deleted tuple doesn't exist!
  4    14
  5     5
  6    16
  7     7
  8    18
  9     9
```

The program listing is shown here:

```
//
//  ndbapi_simple_index_ndbrecord.cpp: Using secondary unique hash indexes
//  in NDB API, utilising the NdbRecord interface.
//
//  Correct output from this program is (from a two-node cluster):
//
// ATTR1 ATTR2
//   0     0   (frag=0)
//   1     1   (frag=1)
//   2     2   (frag=1)
//   3     3   (frag=0)
//   4     4   (frag=1)
//   5     5   (frag=1)
//   6     6   (frag=0)
//   7     7   (frag=0)
//   8     8   (frag=1)
//   9     9   (frag=0)
// ATTR1 ATTR2
//   0    10
```

```
//   1     1
//   2    12
// Detected that deleted tuple doesn't exist!
//   4    14
//   5     5
//   6    16
//   7     7
//   8    18
//   9     9

#include <mysql.h>
#include <NdbApi.hpp>

// Used for cout
#include <stdio.h>
#include <iostream>

#define PRINT_ERROR(code,msg) \
  std::cout << "Error in " << __FILE__ << ", line: " << __LINE__ \
            << ", code: " << code \
            << ", msg: " << msg << "." << std::endl
#define MYSQLERROR(mysql) { \
  PRINT_ERROR(mysql_errno(&mysql),mysql_error(&mysql)); \
  exit(1); }
#define APIERROR(error) { \
  PRINT_ERROR(error.code,error.message); \
  exit(1); }

/* C struct representing layout of data from table
 * api_s_i_ndbrecord in memory
 * This can make it easier to work with rows in the application,
 * but is not necessary - NdbRecord can map columns to any
 * pattern of offsets.
 * In this program, the same row offsets are used for columns
 * specified as part of a key, and as part of an attribute or
 * result.  This makes the example simpler, but is not
 * essential.
 */
struct MyTableRow
{
  unsigned int attr1;
  unsigned int attr2;
};

int main(int argc, char** argv)
{
  if (argc != 3)
    {
    std::cout << "Arguments are <socket mysqld> <connect_string cluster>.\n";
    exit(1);
  }
  char * mysqld_sock  = argv[1];
  const char *connection_string = argv[2];
  ndb_init();
  MYSQL mysql;

  /**************************************************************
   * Connect to mysql server and create table                   *
   **************************************************************/
  {
    if ( !mysql_init(&mysql) ) {
      std::cout << "mysql_init failed\n";
      exit(1);
    }
    if ( !mysql_real_connect(&mysql, "localhost", "root", "", "",
                             0, mysqld_sock, 0) )
      MYSQLERROR(mysql);

    mysql_query(&mysql, "CREATE DATABASE ndb_examples");
    if (mysql_query(&mysql, "USE ndb_examples") != 0)
      MYSQLERROR(mysql);
```

```
  mysql_query(&mysql, "DROP TABLE api_s_i_ndbrecord");
  if (mysql_query(&mysql,
                  "CREATE TABLE"
                  "  api_s_i_ndbrecord"
                  "    (ATTR1 INT UNSIGNED,"
                  "     ATTR2 INT UNSIGNED NOT NULL,"
                  "     PRIMARY KEY USING HASH (ATTR1),"
                  "     UNIQUE MYINDEXNAME USING HASH (ATTR2))"
                  "  ENGINE=NDB"))
    MYSQLERROR(mysql);
}

/**************************************************************
 * Connect to ndb cluster                                     *
 **************************************************************/

Ndb_cluster_connection *cluster_connection=
  new Ndb_cluster_connection(connection_string); // Object representing the cluster

if (cluster_connection->connect(5,3,1))
{
  std::cout << "Connect to cluster management server failed.\n";
  exit(1);
}

if (cluster_connection->wait_until_ready(30,30))
{
  std::cout << "Cluster was not ready within 30 secs.\n";
  exit(1);
}

Ndb* myNdb = new Ndb( cluster_connection,
                      "ndb_examples" );  // Object representing the database
if (myNdb->init() == -1) {
  APIERROR(myNdb->getNdbError());
  exit(1);
}

NdbDictionary::Dictionary* myDict= myNdb->getDictionary();
const NdbDictionary::Table *myTable= myDict->getTable("api_s_i_ndbrecord");
if (myTable == NULL)
  APIERROR(myDict->getNdbError());
const NdbDictionary::Index *myIndex= myDict->getIndex("MYINDEXNAME$unique","api_s_i_ndbrecord");
if (myIndex == NULL)
  APIERROR(myDict->getNdbError());

/* Create NdbRecord descriptors. */
const NdbDictionary::Column *col1= myTable->getColumn("ATTR1");
if (col1 == NULL)
  APIERROR(myDict->getNdbError());
const NdbDictionary::Column *col2= myTable->getColumn("ATTR2");
if (col2 == NULL)
  APIERROR(myDict->getNdbError());

/* NdbRecord for primary key lookup. */
NdbDictionary::RecordSpecification spec[2];
spec[0].column= col1;
spec[0].offset= offsetof(MyTableRow, attr1);
  // So that it goes nicely into the struct
spec[0].nullbit_byte_offset= 0;
spec[0].nullbit_bit_in_byte= 0;
const NdbRecord *pk_record=
  myDict->createRecord(myTable, spec, 1, sizeof(spec[0]));
if (pk_record == NULL)
  APIERROR(myDict->getNdbError());

/* NdbRecord for all table attributes (insert/read). */
spec[0].column= col1;
spec[0].offset= offsetof(MyTableRow, attr1);
spec[0].nullbit_byte_offset= 0;
spec[0].nullbit_bit_in_byte= 0;
spec[1].column= col2;
```

```
spec[1].offset= offsetof(MyTableRow, attr2);
spec[1].nullbit_byte_offset= 0;
spec[1].nullbit_bit_in_byte= 0;
const NdbRecord *attr_record=
  myDict->createRecord(myTable, spec, 2, sizeof(spec[0]));
if (attr_record == NULL)
  APIERROR(myDict->getNdbError());

/* NdbRecord for unique key lookup. */
spec[0].column= col2;
spec[0].offset= offsetof(MyTableRow, attr2);
spec[0].nullbit_byte_offset= 0;
spec[0].nullbit_bit_in_byte= 0;
const NdbRecord *key_record=
  myDict->createRecord(myIndex, spec, 1, sizeof(spec[0]));
if (key_record == NULL)
  APIERROR(myDict->getNdbError());

MyTableRow row;

/**************************************************************************
 * Using 5 transactions, insert 10 tuples in table: (0,0),(1,1),...,(9,9) *
 **************************************************************************/
for (int i = 0; i < 5; i++) {
  NdbTransaction *myTransaction= myNdb->startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb->getNdbError());

  /*
    We initialise the row data and pass to each insertTuple operation
    The data is copied in the call to insertTuple and so the original
    row object can be reused for the two operations.
  */
  row.attr1= row.attr2= i;

  const NdbOperation *myOperation=
    myTransaction->insertTuple(attr_record, (const char*)&row);
  if (myOperation == NULL)
    APIERROR(myTransaction->getNdbError());

  row.attr1= row.attr2= i+5;
  myOperation=
    myTransaction->insertTuple(attr_record, (const char*)&row);
  if (myOperation == NULL)
    APIERROR(myTransaction->getNdbError());

  if (myTransaction->execute( NdbTransaction::Commit ) == -1)
    APIERROR(myTransaction->getNdbError());

  myNdb->closeTransaction(myTransaction);
}

/*****************************************
 * Read and print all tuples using index *
 *****************************************/
std::cout << "ATTR1 ATTR2" << std::endl;

for (int i = 0; i < 10; i++) {
  NdbTransaction *myTransaction= myNdb->startTransaction();
  if (myTransaction == NULL)
    APIERROR(myNdb->getNdbError());

  /* The optional OperationOptions parameter to NdbRecord methods
   * can be used to specify extra reads of columns which are not in
   * the NdbRecord specification, which need to be stored somewhere
   * other than specified in the NdbRecord specification, or
   * which cannot be specified as part of an NdbRecord (pseudo
   * columns)
   */
  Uint32 frag;
  NdbOperation::GetValueSpec getSpec[1];
  getSpec[0].column=NdbDictionary::Column::FRAGMENT;
  getSpec[0].appStorage=&frag;
```

```
  NdbOperation::OperationOptions options;
  options.optionsPresent = NdbOperation::OperationOptions::OO_GETVALUE;
  options.extraGetValues = &getSpec[0];
  options.numExtraGetValues = 1;

  /* We're going to read using the secondary unique hash index
   * Set the value of its column
   */
  row.attr2= i;

  MyTableRow resultRow;

  unsigned char mask[1]= { 0x01 };            // Only read ATTR1 into resultRow
  const NdbOperation *myOperation=
    myTransaction->readTuple(key_record, (const char*) &row,
                             attr_record, (char*) &resultRow,
                             NdbOperation::LM_Read, mask,
                             &options,
                             sizeof(NdbOperation::OperationOptions));
  if (myOperation == NULL)
    APIERROR(myTransaction->getNdbError());

  if (myTransaction->execute( NdbTransaction::Commit,
                              NdbOperation::AbortOnError ) != -1)
  {
    printf(" %2d    %2d   (frag=%u)\n", resultRow.attr1, i, frag);
  }

  myNdb->closeTransaction(myTransaction);
}

/*****************************************************************
 * Update the second attribute in half of the tuples (adding 10) *
 *****************************************************************/
for (int i = 0; i < 10; i+=2) {
  NdbTransaction *myTransaction= myNdb->startTransaction();
  if (myTransaction == NULL)
    APIERROR(myNdb->getNdbError());

  /* Specify key column to lookup in secondary index */
  row.attr2= i;

  /* Specify new column value to set */
  MyTableRow newRowData;
  newRowData.attr2= i+10;
  unsigned char mask[1]= { 0x02 };            // Only update ATTR2

  const NdbOperation *myOperation=
    myTransaction->updateTuple(key_record, (const char*)&row,
                               attr_record,(char*) &newRowData, mask);
  if (myOperation == NULL)
    APIERROR(myTransaction->getNdbError());

  if ( myTransaction->execute( NdbTransaction::Commit ) == -1 )
    APIERROR(myTransaction->getNdbError());

  myNdb->closeTransaction(myTransaction);
}

/*************************************************
 * Delete one tuple (the one with unique key 3) *
 *************************************************/
{
  NdbTransaction *myTransaction= myNdb->startTransaction();
  if (myTransaction == NULL)
    APIERROR(myNdb->getNdbError());

  row.attr2= 3;
  const NdbOperation *myOperation=
    myTransaction->deleteTuple(key_record, (const char*) &row,
                               attr_record);
```

```
    if (myOperation == NULL)
      APIERROR(myTransaction->getNdbError());

    if (myTransaction->execute(NdbTransaction::Commit) == -1)
      APIERROR(myTransaction->getNdbError());

    myNdb->closeTransaction(myTransaction);
  }

  /*****************************
   * Read and print all tuples *
   *****************************/
  {
    std::cout << "ATTR1 ATTR2" << std::endl;

    for (int i = 0; i < 10; i++) {
      NdbTransaction *myTransaction= myNdb->startTransaction();
      if (myTransaction == NULL)
        APIERROR(myNdb->getNdbError());

      row.attr1= i;

      /* Read using pk.  Note the same row space is used as
       * key and result storage space
       */
      const NdbOperation *myOperation=
        myTransaction->readTuple(pk_record, (const char*) &row,
                                 attr_record, (char*) &row);
      if (myOperation == NULL)
        APIERROR(myTransaction->getNdbError());

      if (myTransaction->execute( NdbTransaction::Commit,
                                  NdbOperation::AbortOnError ) == -1)
        if (i == 3) {
          std::cout << "Detected that deleted tuple doesn't exist!\n";
        } else {
          APIERROR(myTransaction->getNdbError());
        }

      if (i != 3)
        printf(" %2d    %2d\n", row.attr1, row.attr2);

      myNdb->closeTransaction(myTransaction);
    }
  }

  delete myNdb;
  delete cluster_connection;

  ndb_end(0);
  return 0;
}
```

2.5.7 NDB API Example Comparing RecAttr and NdbRecord

This example illustrates the key differences between the old-style `NdbRecAttr` API and the newer approach using `NdbRecord` when performing some common tasks in an NDB API application.

The source code can be found can be found in the file `storage/ndb/ndbapi-examples/ndbapi_recattr_vs_record/main.cpp` in the NDB Cluster source tree.

```
#include <mysql.h>
#include <NdbApi.hpp>

// Used for cout
#include <stdio.h>
#include <iostream>

// Do we use old-style (NdbRecAttr?) or new style (NdbRecord?)
enum ApiType {api_attr, api_record};
```

```
static void run_application(MYSQL &, Ndb_cluster_connection &, ApiType);

#define PRINT_ERROR(code,msg) \
  std::cout << "Error in " << __FILE__ \
            << ", line: " << __LINE__ \
            << ", code: " << code \
            << ", msg: " << msg << "." << std::endl
#define MYSQLERROR(mysql) { \
  PRINT_ERROR(mysql_errno(&mysql),mysql_error(&mysql)); \
  exit(-1); }
#define APIERROR(error) { \
  PRINT_ERROR(error.code,error.message); \
  exit(-1); }

int main(int argc, char** argv)
{
  if (argc != 4)
  {
    std::cout << "Arguments are <socket mysqld> "
              << "<connect_string cluster> <attr|record>.\n";
    exit(-1);
  }
  // ndb_init must be called first
  ndb_init();

  // connect to mysql server and cluster and run application
  {
    char * mysqld_sock  = argv[1];
    const char *connection_string = argv[2];
    ApiType accessType=api_attr;

    // Object representing the cluster
    Ndb_cluster_connection cluster_connection(connection_string);

    // Connect to cluster management server (ndb_mgmd)
    if (cluster_connection.connect(4 /* retries               */,
       5 /* delay between retries */,
       1 /* verbose               */))
    {
      std::cout << "Management server not ready within 30 sec.\n";
      exit(-1);
    }

    // Optionally connect and wait for the storage nodes (ndbd's)
    if (cluster_connection.wait_until_ready(30,0) < 0)
    {
      std::cout << "Cluster not ready within 30 sec.\n";
      exit(-1);
    }

    // connect to mysql server
    MYSQL mysql;
    if ( !mysql_init(&mysql) ) {
      std::cout << "mysql_init failed\n";
      exit(-1);
    }
    if ( !mysql_real_connect(&mysql, "localhost", "root", "", "",
        0, mysqld_sock, 0) )
      MYSQLERROR(mysql);

    if (0==strncmp("attr", argv[3], 4))
    {
      accessType=api_attr;
    }
    else if (0==strncmp("record", argv[3], 6))
    {
      accessType=api_record;
    }
    else
    {
      std::cout << "Bad access type argument : "
                << argv[3] << "\n";
```

```
      exit(-1);
    }

    // run the application code
    run_application(mysql, cluster_connection, accessType);
  }

  ndb_end(0);

  return 0;
}

static void init_ndbrecord_info(Ndb &);
static void create_table(MYSQL &);
static void do_insert(Ndb &, ApiType);
static void do_update(Ndb &, ApiType);
static void do_delete(Ndb &, ApiType);
static void do_read(Ndb &, ApiType);
static void do_mixed_read(Ndb &);
static void do_mixed_update(Ndb &);
static void do_scan(Ndb &, ApiType);
static void do_mixed_scan(Ndb &);
static void do_indexScan(Ndb &, ApiType);
static void do_mixed_indexScan(Ndb&);
static void do_read_and_delete(Ndb &);
static void do_scan_update(Ndb&, ApiType);
static void do_scan_delete(Ndb&, ApiType);
static void do_scan_lock_reread(Ndb&, ApiType);
static void do_all_extras_read(Ndb &myNdb);
static void do_secondary_indexScan(Ndb &myNdb, ApiType accessType);
static void do_secondary_indexScanEqual(Ndb &myNdb, ApiType accessType);
static void do_interpreted_update(Ndb &myNdb, ApiType accessType);
static void do_interpreted_scan(Ndb &myNdb, ApiType accessType);
static void do_read_using_default(Ndb &myNdb);

/* This structure is used describe how we want data read using
 * NDBRecord to be placed into memory.  This can make it easier
 * to work with data, but is not essential.
 */
struct RowData
{
  int attr1;
  int attr2;
  int attr3;
};


/* Handy struct for representing the data in the
 * secondary index
 */
struct IndexRow
{
  unsigned int attr3;
  unsigned int attr2;
};

static void run_application(MYSQL &mysql,
       Ndb_cluster_connection &cluster_connection,
                           ApiType accessType)
{
  /********************************************
   * Connect to database via mysql-c          *
   ********************************************/
  mysql_query(&mysql, "CREATE DATABASE ndb_examples");
  if (mysql_query(&mysql, "USE ndb_examples") != 0) MYSQLERROR(mysql);
  create_table(mysql);

  /********************************************
   * Connect to database via NDB API           *
   ********************************************/
  // Object representing the database
  Ndb myNdb( &cluster_connection, "ndb_examples" );
```

```
  if (myNdb.init()) APIERROR(myNdb.getNdbError());

  init_ndbrecord_info(myNdb);
  /*
   * Do different operations on database
   */
  do_insert(myNdb, accessType);
  do_update(myNdb, accessType);
  do_delete(myNdb, accessType);
  do_read(myNdb, accessType);
  do_mixed_read(myNdb);
  do_mixed_update(myNdb);
  do_read(myNdb, accessType);
  do_scan(myNdb, accessType);
  do_mixed_scan(myNdb);
  do_indexScan(myNdb, accessType);
  do_mixed_indexScan(myNdb);
  do_read_and_delete(myNdb);
  do_scan_update(myNdb, accessType);
  do_scan_delete(myNdb, accessType);
  do_scan_lock_reread(myNdb, accessType);
  do_all_extras_read(myNdb);
  do_secondary_indexScan(myNdb, accessType);
  do_secondary_indexScanEqual(myNdb, accessType);
  do_scan(myNdb, accessType);
  do_interpreted_update(myNdb, accessType);
  do_interpreted_scan(myNdb, accessType);
  do_read_using_default(myNdb);
  do_scan(myNdb, accessType);
}

/*********************************************************
 * Create a table named api_recattr_vs_record if it does not exist *
 *********************************************************/
static void create_table(MYSQL &mysql)
{
  if (mysql_query(&mysql,
    "DROP TABLE IF EXISTS"
    "  api_recattr_vs_record"))
    MYSQLERROR(mysql);

  if (mysql_query(&mysql,
    "CREATE TABLE"
    "  api_recattr_vs_record"
    "    (ATTR1 INT UNSIGNED NOT NULL PRIMARY KEY,"
    "     ATTR2 INT UNSIGNED NOT NULL,"
                  "     ATTR3 INT UNSIGNED NOT NULL)"
    "  ENGINE=NDB"))
    MYSQLERROR(mysql);

  /* Add ordered secondary index on 2 attributes, in reverse order */
  if (mysql_query(&mysql,
                  "CREATE INDEX"
                  "  MYINDEXNAME"
                  "  ON api_recattr_vs_record"
                  "  (ATTR3, ATTR2)"))
    MYSQLERROR(mysql);
}


/* Clunky statics for shared NdbRecord stuff */
static const NdbDictionary::Column *pattr1Col;
static const NdbDictionary::Column *pattr2Col;
static const NdbDictionary::Column *pattr3Col;

static const NdbRecord *pkeyColumnRecord;
static const NdbRecord *pallColsRecord;
static const NdbRecord *pkeyIndexRecord;
static const NdbRecord *psecondaryIndexRecord;

static int attr1ColNum;
static int attr2ColNum;
```

```
static int attr3ColNum;

/**************************************************************
 * Initialise NdbRecord structures for table and index access *
 **************************************************************/
static void init_ndbrecord_info(Ndb &myNdb)
{
  /* Here we create various NdbRecord structures for accessing
   * data using the tables and indexes on api_recattr_vs_record
   * We could use the default NdbRecord structures, but then
   * we wouldn't have the nice ability to read and write rows
   * to and from the RowData and IndexRow structs
   */
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable=
                  myDict->getTable("api_recattr_vs_record");

  NdbDictionary::RecordSpecification recordSpec[3];

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  pattr1Col = myTable->getColumn("ATTR1");
  if (pattr1Col == NULL) APIERROR(myDict->getNdbError());
  pattr2Col = myTable->getColumn("ATTR2");
  if (pattr2Col == NULL) APIERROR(myDict->getNdbError());
  pattr3Col = myTable->getColumn("ATTR3");
  if (pattr3Col == NULL) APIERROR(myDict->getNdbError());

  attr1ColNum = pattr1Col->getColumnNo();
  attr2ColNum = pattr2Col->getColumnNo();
  attr3ColNum = pattr3Col->getColumnNo();

  // ATTR 1
  recordSpec[0].column = pattr1Col;
  recordSpec[0].offset = offsetof(RowData, attr1);
  recordSpec[0].nullbit_byte_offset = 0; // Not nullable
  recordSpec[0].nullbit_bit_in_byte = 0;

  // ATTR 2
  recordSpec[1].column = pattr2Col;
  recordSpec[1].offset = offsetof(RowData, attr2);
  recordSpec[1].nullbit_byte_offset = 0;   // Not nullable
  recordSpec[1].nullbit_bit_in_byte = 0;

  // ATTR 3
  recordSpec[2].column = pattr3Col;
  recordSpec[2].offset = offsetof(RowData, attr3);
  recordSpec[2].nullbit_byte_offset = 0;   // Not nullable
  recordSpec[2].nullbit_bit_in_byte = 0;

  /* Create table record with just the primary key column */
  pkeyColumnRecord =
    myDict->createRecord(myTable, recordSpec, 1, sizeof(recordSpec[0]));

  if (pkeyColumnRecord == NULL) APIERROR(myDict->getNdbError());

  /* Create table record with all the columns */
  pallColsRecord =
    myDict->createRecord(myTable, recordSpec, 3, sizeof(recordSpec[0]));

  if (pallColsRecord == NULL) APIERROR(myDict->getNdbError());

  /* Create NdbRecord for primary index access */
  const NdbDictionary::Index *myPIndex=
                  myDict->getIndex("PRIMARY", "api_recattr_vs_record");

  if (myPIndex == NULL)
    APIERROR(myDict->getNdbError());

  pkeyIndexRecord =
    myDict->createRecord(myPIndex, recordSpec, 1, sizeof(recordSpec[0]));
```

```
  if (pkeyIndexRecord == NULL) APIERROR(myDict->getNdbError());

  /* Create Index NdbRecord for secondary index access
   * Note that we use the columns from the table to define the index
   * access record
   */
  const NdbDictionary::Index *mySIndex=
              myDict->getIndex("MYINDEXNAME", "api_recattr_vs_record");

  recordSpec[0].column= pattr3Col;
  recordSpec[0].offset= offsetof(IndexRow, attr3);
  recordSpec[0].nullbit_byte_offset=0;
  recordSpec[0].nullbit_bit_in_byte=0;

  recordSpec[1].column= pattr2Col;
  recordSpec[1].offset= offsetof(IndexRow, attr2);
  recordSpec[1].nullbit_byte_offset=0;
  recordSpec[1].nullbit_bit_in_byte=1;

  /* Create NdbRecord for accessing via secondary index */
  psecondaryIndexRecord =
    myDict->createRecord(mySIndex,
                         recordSpec,
                         2,
                         sizeof(recordSpec[0]));


  if (psecondaryIndexRecord == NULL)
    APIERROR(myDict->getNdbError());

}


/**************************************************************************
 * Using 5 transactions, insert 10 tuples in table: (0,0),(1,1),...,(9,9) *
 **************************************************************************/
static void do_insert(Ndb &myNdb, ApiType accessType)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable=
                          myDict->getTable("api_recattr_vs_record");

  std::cout << "Running do_insert\n";

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  for (int i = 0; i < 5; i++) {
    NdbTransaction *myTransaction= myNdb.startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

    switch (accessType)
    {
    case api_attr :
      {
        NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
        if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

        myOperation->insertTuple();
        myOperation->equal("ATTR1", i);
        myOperation->setValue("ATTR2", i);
        myOperation->setValue("ATTR3", i);

        myOperation= myTransaction->getNdbOperation(myTable);

        if (myOperation == NULL) APIERROR(myTransaction->getNdbError());
        myOperation->insertTuple();
        myOperation->equal("ATTR1", i+5);
        myOperation->setValue("ATTR2", i+5);
        myOperation->setValue("ATTR3", i+5);
        break;
```

```
      }
    case api_record :
      {
        RowData row;

        row.attr1= row.attr2= row.attr3= i;

        const NdbOperation *pop1=
          myTransaction->insertTuple(pallColsRecord, (char *) &row);
        if (pop1 == NULL) APIERROR(myTransaction->getNdbError());

        row.attr1= row.attr2= row.attr3= i+5;

        const NdbOperation *pop2=
          myTransaction->insertTuple(pallColsRecord, (char *) &row);
        if (pop2 == NULL) APIERROR(myTransaction->getNdbError());

        break;
      }
    default :
      {
        std::cout << "Bad branch : " << accessType << "\n";
        exit(-1);
      }
    }

    if (myTransaction->execute( NdbTransaction::Commit ) == -1)
      APIERROR(myTransaction->getNdbError());

    myNdb.closeTransaction(myTransaction);
  }

  std::cout << "-------\n";
}

/*****************************************************************
 * Update the second attribute in half of the tuples (adding 10) *
 *****************************************************************/
static void do_update(Ndb &myNdb, ApiType accessType)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable=
                            myDict->getTable("api_recattr_vs_record");

  std::cout << "Running do_update\n";

  for (int i = 0; i < 10; i+=2) {
    NdbTransaction *myTransaction= myNdb.startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

    switch (accessType)
    {
      case api_attr :
      {
        NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
        if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

        myOperation->updateTuple();
        myOperation->equal( "ATTR1", i );
        myOperation->setValue( "ATTR2", i+10);
        myOperation->setValue( "ATTR3", i+20);
        break;
      }
      case api_record :
      {
        RowData row;
        row.attr1=i;
        row.attr2=i+10;
        row.attr3=i+20;

        /* Since we're using an NdbRecord with all columns in it to
         * specify the updated columns, we need to create a mask to
```

```
         * indicate that we are only updating attr2 and attr3.
         */
        unsigned char attrMask=(1<<attr2ColNum) | (1<<attr3ColNum);

        const NdbOperation *pop =
          myTransaction->updateTuple(pkeyColumnRecord, (char*) &row,
                                     pallColsRecord, (char*) &row,
                                     &attrMask);

        if (pop==NULL) APIERROR(myTransaction->getNdbError());
        break;
      }
    default :
      {
        std::cout << "Bad branch : " << accessType << "\n";
        exit(-1);
      }
    }

    if( myTransaction->execute( NdbTransaction::Commit ) == -1 )
      APIERROR(myTransaction->getNdbError());

    myNdb.closeTransaction(myTransaction);
  }

  std::cout << "-------\n";
};

/*************************************************
 * Delete one tuple (the one with primary key 3) *
 *************************************************/
static void do_delete(Ndb &myNdb, ApiType accessType)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable=
                           myDict->getTable("api_recattr_vs_record");

  std::cout << "Running do_delete\n";

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  NdbTransaction *myTransaction= myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  switch (accessType)
  {
  case api_attr :
    {
      NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
      if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

      myOperation->deleteTuple();
      myOperation->equal( "ATTR1", 3 );
      break;
    }
  case api_record :
    {
      RowData keyInfo;
      keyInfo.attr1=3;

      const NdbOperation *pop=
        myTransaction->deleteTuple(pkeyColumnRecord,
                                   (char*) &keyInfo,
                                   pallColsRecord);

      if (pop==NULL) APIERROR(myTransaction->getNdbError());
      break;
    }
  default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
```

```
      exit(-1);
    }
  }


  if (myTransaction->execute(NdbTransaction::Commit) == -1)
    APIERROR(myTransaction->getNdbError());

  myNdb.closeTransaction(myTransaction);

  std::cout << "-------\n";
}


/*****************************************************************
 * Update the second attribute in half of the tuples (adding 10) *
 *****************************************************************/
static void do_mixed_update(Ndb &myNdb)
{
  /* This method performs an update using a mix of NdbRecord
   * supplied attributes, and extra setvalues provided by
   * the OperationOptions structure.
   */
  std::cout << "Running do_mixed_update (NdbRecord only)\n";

  for (int i = 0; i < 10; i+=2) {
    NdbTransaction *myTransaction= myNdb.startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

    RowData row;
    row.attr1=i;
    row.attr2=i+30;

    /* Only attr2 is updated vian NDBRecord */
    unsigned char attrMask= (1<<attr2ColNum);

    NdbOperation::SetValueSpec setvalspecs[1];

    /* Value to set attr3 to */
    Uint32 dataSource= i + 40;

    setvalspecs[0].column = pattr3Col;
    setvalspecs[0].value = &dataSource;

    NdbOperation::OperationOptions opts;
    opts.optionsPresent= NdbOperation::OperationOptions::OO_SETVALUE;
    opts.extraSetValues= &setvalspecs[0];
    opts.numExtraSetValues= 1;


    // Define mixed operation in one call to NDBAPI
    const NdbOperation *pop =
      myTransaction->updateTuple(pkeyColumnRecord, (char*) &row,
                                 pallColsRecord, (char*) &row,
                                 &attrMask,
                                 &opts);

    if (pop==NULL) APIERROR(myTransaction->getNdbError());

    if( myTransaction->execute( NdbTransaction::Commit ) == -1 )
      APIERROR(myTransaction->getNdbError());

    myNdb.closeTransaction(myTransaction);
  }

  std::cout << "-------\n";
}


/*********************************************
 * Read and print all tuples using PK access *
 *********************************************/
```

```
static void do_read(Ndb &myNdb, ApiType accessType)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable=
                            myDict->getTable("api_recattr_vs_record");

  std::cout << "Running do_read\n";

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  std::cout << "ATTR1 ATTR2 ATTR3" << std::endl;

  for (int i = 0; i < 10; i++) {
    NdbTransaction *myTransaction= myNdb.startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

    RowData rowData;
    NdbRecAttr *myRecAttr;
    NdbRecAttr *myRecAttr2;

    switch (accessType)
    {
      case api_attr :
      {
        NdbOperation *myOperation= myTransaction->getNdbOperation(myTable);
        if (myOperation == NULL) APIERROR(myTransaction->getNdbError());

        myOperation->readTuple(NdbOperation::LM_Read);
        myOperation->equal("ATTR1", i);

        myRecAttr= myOperation->getValue("ATTR2", NULL);
        if (myRecAttr == NULL) APIERROR(myTransaction->getNdbError());

        myRecAttr2=myOperation->getValue("ATTR3", NULL);
        if (myRecAttr2 == NULL) APIERROR(myTransaction->getNdbError());

        break;
      }
      case api_record :
      {
        rowData.attr1=i;
        const NdbOperation *pop=
          myTransaction->readTuple(pkeyColumnRecord,
                                   (char*) &rowData,
                                   pallColsRecord,  // Read PK+ATTR2+ATTR3
                                   (char*) &rowData);
        if (pop==NULL) APIERROR(myTransaction->getNdbError());

        break;
      }
    default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
    }

    if(myTransaction->execute( NdbTransaction::Commit ) == -1)
      APIERROR(myTransaction->getNdbError());

    if (myTransaction->getNdbError().classification == NdbError::NoDataFound)
      if (i == 3)
        std::cout << "Deleted tuple does not exist." << std::endl;
      else
 APIERROR(myTransaction->getNdbError());

    switch (accessType)
    {
      case api_attr :
      {
        if (i != 3) {
```

```
          printf(" %2d    %2d    %2d\n",
                 i,
                 myRecAttr->u_32_value(),
                 myRecAttr2->u_32_value());
        }
        break;
      }
      case api_record :
      {
        if (i !=3) {
          printf(" %2d    %2d    %2d\n",
                 i,
                 rowData.attr2,
                 rowData.attr3);
        }
        break;
      }
      default :
      {
        std::cout << "Bad branch : " << accessType << "\n";
        exit(-1);
      }
    }

    myNdb.closeTransaction(myTransaction);
  }

  std::cout << "-------\n";
}

/*****************************
 * Read and print all tuples *
 *****************************/
static void do_mixed_read(Ndb &myNdb)
{
  std::cout << "Running do_mixed_read (NdbRecord only)\n";

  std::cout << "ATTR1 ATTR2 ATTR3 COMMIT_COUNT" << std::endl;

  for (int i = 0; i < 10; i++) {
    NdbTransaction *myTransaction= myNdb.startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

    RowData rowData;
    NdbRecAttr *myRecAttr3, *myRecAttrCC;

    /* Start with NdbRecord read of ATTR2, and then add
     * getValue NdbRecAttr read of ATTR3 and Commit count
     */
    NdbOperation::GetValueSpec extraCols[2];

    extraCols[0].column=pattr3Col;
    extraCols[0].appStorage=NULL;
    extraCols[0].recAttr=NULL;

    extraCols[1].column=NdbDictionary::Column::COMMIT_COUNT;
    extraCols[1].appStorage=NULL;
    extraCols[1].recAttr=NULL;

    NdbOperation::OperationOptions opts;
    opts.optionsPresent = NdbOperation::OperationOptions::OO_GETVALUE;

    opts.extraGetValues= &extraCols[0];
    opts.numExtraGetValues= 2;

    /* We only read attr2 using the normal NdbRecord access */
    unsigned char attrMask= (1<<attr2ColNum);

    // Set PK search criteria
    rowData.attr1= i;

    const NdbOperation *pop=
```

```
      myTransaction->readTuple(pkeyColumnRecord,
                               (char*) &rowData,
                               pallColsRecord,  // Read all with mask
                               (char*) &rowData,
                               NdbOperation::LM_Read,
                               &attrMask, // result_mask
                               &opts);
    if (pop==NULL) APIERROR(myTransaction->getNdbError());

    myRecAttr3= extraCols[0].recAttr;
    myRecAttrCC= extraCols[1].recAttr;

    if (myRecAttr3 == NULL) APIERROR(myTransaction->getNdbError());
    if (myRecAttrCC == NULL) APIERROR(myTransaction->getNdbError());


    if(myTransaction->execute( NdbTransaction::Commit ) == -1)
      APIERROR(myTransaction->getNdbError());

    if (myTransaction->getNdbError().classification == NdbError::NoDataFound)
      if (i == 3)
        std::cout << "Deleted tuple does not exist." << std::endl;
      else
 APIERROR(myTransaction->getNdbError());


    if (i !=3) {
      printf(" %2d    %2d    %2d    %d\n",
             rowData.attr1,
             rowData.attr2,
             myRecAttr3->u_32_value(),
             myRecAttrCC->u_32_value()
             );
    }

    myNdb.closeTransaction(myTransaction);
  }

  std::cout << "-------\n";
}

/*********************************************
 * Read and print all tuples via table scan *
 *********************************************/
static void do_scan(Ndb &myNdb, ApiType accessType)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable=
                          myDict->getTable("api_recattr_vs_record");

  std::cout << "Running do_scan\n";

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  std::cout << "ATTR1 ATTR2 ATTR3" << std::endl;

  NdbTransaction *myTransaction=myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  NdbScanOperation *psop;
  NdbRecAttr *recAttrAttr1;
  NdbRecAttr *recAttrAttr2;
  NdbRecAttr *recAttrAttr3;

  switch (accessType)
  {
    case api_attr :
    {
      psop=myTransaction->getNdbScanOperation(myTable);

      if (psop == NULL) APIERROR(myTransaction->getNdbError());
```

```
      if (psop->readTuples(NdbOperation::LM_Read) != 0)
        APIERROR (myTransaction->getNdbError());

      recAttrAttr1=psop->getValue("ATTR1");
      recAttrAttr2=psop->getValue("ATTR2");
      recAttrAttr3=psop->getValue("ATTR3");

      break;
    }
    case api_record :
    {
      /* Note that no row ptr is passed to the NdbRecord scan operation
       * The scan will fetch a batch and give the user a series of pointers
       * to rows in the batch in nextResult() below
       */
      psop=myTransaction->scanTable(pallColsRecord,
                                    NdbOperation::LM_Read);

      if (psop == NULL) APIERROR(myTransaction->getNdbError());

      break;
    }
  default :
  {
    std::cout << "Bad branch : " << accessType << "\n";
    exit(-1);
  }
  }

  if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
    APIERROR(myTransaction->getNdbError());

  switch (accessType)
  {
  case api_attr :
  {
    while (psop->nextResult(true) == 0)
    {
      printf(" %2d    %2d    %2d\n",
             recAttrAttr1->u_32_value(),
             recAttrAttr2->u_32_value(),
             recAttrAttr3->u_32_value());
    }

    psop->close();

    break;
  }
  case api_record :
  {
    RowData *prowData; // Ptr to point to our data

    int rc=0;

    /* Ask nextResult to update out ptr to point to the next
     * row from the scan
     */
    while ((rc = psop->nextResult((const char**) &prowData,
                                  true,
                                  false)) == 0)
    {
      printf(" %2d    %2d    %2d\n",
             prowData->attr1,
             prowData->attr2,
             prowData->attr3);
    }

    if (rc != 1)  APIERROR(myTransaction->getNdbError());

    psop->close(true);
```

```
    break;
  }
  default :
  {
    std::cout << "Bad branch : " << accessType << "\n";
    exit(-1);
  }
  }

  if(myTransaction->execute( NdbTransaction::Commit ) !=0)
    APIERROR(myTransaction->getNdbError());

  myNdb.closeTransaction(myTransaction);

  std::cout << "-------\n";
}

/*************************************************************
 * Read and print all tuples via table scan and mixed read *
 *************************************************************/
static void do_mixed_scan(Ndb &myNdb)
{
  std::cout << "Running do_mixed_scan(NdbRecord only)\n";

  std::cout << "ATTR1 ATTR2 ATTR3" << std::endl;

  NdbTransaction *myTransaction=myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  NdbScanOperation *psop;
  NdbRecAttr *recAttrAttr3;

  /* Set mask so that NdbRecord scan reads attr1 and attr2 only */
  unsigned char attrMask=((1<<attr1ColNum) | (1<<attr2ColNum));

  /* Define extra get value to get attr3 */
  NdbOperation::GetValueSpec extraGets[1];
  extraGets[0].column = pattr3Col;
  extraGets[0].appStorage= 0;
  extraGets[0].recAttr= 0;

  NdbScanOperation::ScanOptions options;
  options.optionsPresent= NdbScanOperation::ScanOptions::SO_GETVALUE;
  options.extraGetValues= &extraGets[0];
  options.numExtraGetValues= 1;

  psop=myTransaction->scanTable(pallColsRecord,
                                NdbOperation::LM_Read,
                                &attrMask,
                                &options,
                                sizeof(NdbScanOperation::ScanOptions));
  if (psop == NULL) APIERROR(myTransaction->getNdbError());

  /* RecAttr for the extra get has been set by the operation definition */
  recAttrAttr3 = extraGets[0].recAttr;

  if (recAttrAttr3 == NULL) APIERROR(myTransaction->getNdbError());

  if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
    APIERROR(myTransaction->getNdbError());

  RowData *prowData; // Ptr to point to our data

  int rc=0;

  while ((rc = psop->nextResult((const char**) &prowData,
                                true,
                                false)) == 0)
  {
    printf(" %2d    %2d    %2d\n",
           prowData->attr1,
           prowData->attr2,
```

```
          recAttrAttr3->u_32_value());
  }

  if (rc != 1)  APIERROR(myTransaction->getNdbError());

  psop->close(true);

  if(myTransaction->execute( NdbTransaction::Commit ) !=0)
    APIERROR(myTransaction->getNdbError());

  myNdb.closeTransaction(myTransaction);

  std::cout << "-------\n";
}



/*************************************************************
 * Read and print all tuples via primary ordered index scan *
 *************************************************************/
static void do_indexScan(Ndb &myNdb, ApiType accessType)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Index *myPIndex=
                myDict->getIndex("PRIMARY", "api_recattr_vs_record");

  std::cout << "Running do_indexScan\n";

  if (myPIndex == NULL)
    APIERROR(myDict->getNdbError());

  std::cout << "ATTR1 ATTR2 ATTR3" << std::endl;

  NdbTransaction *myTransaction=myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  NdbIndexScanOperation *psop;

  /* RecAttrs for NdbRecAttr Api */
  NdbRecAttr *recAttrAttr1;
  NdbRecAttr *recAttrAttr2;
  NdbRecAttr *recAttrAttr3;

  switch (accessType)
  {
    case api_attr :
    {
      psop=myTransaction->getNdbIndexScanOperation(myPIndex);

      if (psop == NULL) APIERROR(myTransaction->getNdbError());

      /* Multi read range is not supported for the NdbRecAttr scan
       * API, so we just read one range.
       */
      Uint32 scanFlags=
        NdbScanOperation::SF_OrderBy |
        NdbScanOperation::SF_MultiRange |
        NdbScanOperation::SF_ReadRangeNo;

      if (psop->readTuples(NdbOperation::LM_Read,
                           scanFlags,
                           (Uint32) 0,          // batch
                           (Uint32) 0) != 0)    // parallel
        APIERROR (myTransaction->getNdbError());

      /* Add a bound
       * Tuples where ATTR1 >=2 and < 4
       * 2,[3 deleted]
       */
      Uint32 low=2;
      Uint32 high=4;
```

```
    if (psop->setBound("ATTR1",
                       NdbIndexScanOperation::BoundLE, (char*)&low))
      APIERROR(myTransaction->getNdbError());

    if (psop->setBound("ATTR1",
                       NdbIndexScanOperation::BoundGT, (char*)&high))
      APIERROR(myTransaction->getNdbError());

    if (psop->end_of_bound(0))
      APIERROR(psop->getNdbError());

    /* Second bound
     * Tuples where ATTR1 > 5 and <=9
     * 6,7,8,9
     */
    low=5;
    high=9;
    if (psop->setBound("ATTR1",
                       NdbIndexScanOperation::BoundLT, (char*)&low))
      APIERROR(myTransaction->getNdbError());

    if (psop->setBound("ATTR1",
                       NdbIndexScanOperation::BoundGE, (char*)&high))
      APIERROR(myTransaction->getNdbError());

    if (psop->end_of_bound(1))
      APIERROR(psop->getNdbError());

    /* Read all columns */
    recAttrAttr1=psop->getValue("ATTR1");
    recAttrAttr2=psop->getValue("ATTR2");
    recAttrAttr3=psop->getValue("ATTR3");

    break;
  }
  case api_record :
  {
    /* NdbRecord supports scanning multiple ranges using a
     * single index scan operation
     */
    Uint32 scanFlags =
      NdbScanOperation::SF_OrderBy |
      NdbScanOperation::SF_MultiRange |
      NdbScanOperation::SF_ReadRangeNo;

    NdbScanOperation::ScanOptions options;
    options.optionsPresent=NdbScanOperation::ScanOptions::SO_SCANFLAGS;
    options.scan_flags=scanFlags;

    psop=myTransaction->scanIndex(pkeyIndexRecord,
                                  pallColsRecord,
                                  NdbOperation::LM_Read,
                                  NULL, // no mask; read all columns
                                        // in result record
                                  NULL, // bound defined later
                                  &options,
                                  sizeof(NdbScanOperation::ScanOptions));

    if (psop == NULL) APIERROR(myTransaction->getNdbError());

    /* Add a bound
     * Tuples where ATTR1 >=2 and < 4
     * 2,[3 deleted]
     */
    Uint32 low=2;
    Uint32 high=4;

    NdbIndexScanOperation::IndexBound bound;
    bound.low_key=(char*)&low;
    bound.low_key_count=1;
    bound.low_inclusive=true;
    bound.high_key=(char*)&high;
```

```
      bound.high_key_count=1;
      bound.high_inclusive=false;
      bound.range_no=0;

      if (psop->setBound(pkeyIndexRecord, bound))
        APIERROR(myTransaction->getNdbError());

      /* Second bound
       * Tuples where ATTR1 > 5 and <=9
       * 6,7,8,9
       */
      low=5;
      high=9;

      bound.low_key=(char*)&low;
      bound.low_key_count=1;
      bound.low_inclusive=false;
      bound.high_key=(char*)&high;
      bound.high_key_count=1;
      bound.high_inclusive=true;
      bound.range_no=1;

      if (psop->setBound(pkeyIndexRecord, bound))
        APIERROR(myTransaction->getNdbError());

      break;
    }
  default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
  }

  if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
    APIERROR(myTransaction->getNdbError());

  if (myTransaction->getNdbError().code != 0)
    APIERROR(myTransaction->getNdbError());

  switch (accessType)
  {
    case api_attr :
    {
      while (psop->nextResult(true) == 0)
      {
        printf(" %2d    %2d    %2d    Range no : %2d\n",
               recAttrAttr1->u_32_value(),
               recAttrAttr2->u_32_value(),
               recAttrAttr3->u_32_value(),
               psop->get_range_no());
      }

      psop->close();

      break;
    }
    case api_record :
    {
      RowData *prowData; // Ptr to point to our data

      int rc=0;

      while ((rc = psop->nextResult((const char**) &prowData,
                                    true,
                                    false)) == 0)
      {
        // printf(" PTR : %d\n", (int) prowData);
        printf(" %2d    %2d    %2d    Range no : %2d\n",
               prowData->attr1,
               prowData->attr2,
               prowData->attr3,
```

```
              psop->get_range_no());
      }

      if (rc != 1)  APIERROR(myTransaction->getNdbError());

      psop->close(true);

      break;
    }
    default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
  }

  if(myTransaction->execute( NdbTransaction::Commit ) !=0)
    APIERROR(myTransaction->getNdbError());

  myNdb.closeTransaction(myTransaction);

  std::cout << "-------\n";
}



/**************************************************************************
 * Read and print all tuples via index scan using mixed NdbRecord access *
 **************************************************************************/
static void do_mixed_indexScan(Ndb &myNdb)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Index *myPIndex=
                    myDict->getIndex("PRIMARY", "api_recattr_vs_record");

  std::cout << "Running do_mixed_indexScan\n";

  if (myPIndex == NULL)
    APIERROR(myDict->getNdbError());

  std::cout << "ATTR1 ATTR2 ATTR3" << std::endl;

  NdbTransaction *myTransaction=myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  NdbIndexScanOperation *psop;
  NdbRecAttr *recAttrAttr3;

  Uint32 scanFlags =
    NdbScanOperation::SF_OrderBy |
    NdbScanOperation::SF_MultiRange |
    NdbScanOperation::SF_ReadRangeNo;

  /* We'll get Attr3 via ScanOptions */
  unsigned char attrMask=((1<<attr1ColNum) | (1<<attr2ColNum));

  NdbOperation::GetValueSpec extraGets[1];
  extraGets[0].column= pattr3Col;
  extraGets[0].appStorage= NULL;
  extraGets[0].recAttr= NULL;

  NdbScanOperation::ScanOptions options;
  options.optionsPresent=
    NdbScanOperation::ScanOptions::SO_SCANFLAGS |
    NdbScanOperation::ScanOptions::SO_GETVALUE;
  options.scan_flags= scanFlags;
  options.extraGetValues= &extraGets[0];
  options.numExtraGetValues= 1;

  psop=myTransaction->scanIndex(pkeyIndexRecord,
                                pallColsRecord,
                                NdbOperation::LM_Read,
```

```
                              &attrMask, // mask
                              NULL, // bound defined below
                              &options,
                              sizeof(NdbScanOperation::ScanOptions));

  if (psop == NULL) APIERROR(myTransaction->getNdbError());

  /* Grab RecAttr now */
  recAttrAttr3= extraGets[0].recAttr;

  /* Add a bound
   * ATTR1 >= 2, < 4
   * 2,[3 deleted]
   */
  Uint32 low=2;
  Uint32 high=4;

  NdbIndexScanOperation::IndexBound bound;
  bound.low_key=(char*)&low;
  bound.low_key_count=1;
  bound.low_inclusive=true;
  bound.high_key=(char*)&high;
  bound.high_key_count=1;
  bound.high_inclusive=false;
  bound.range_no=0;

  if (psop->setBound(pkeyIndexRecord, bound))
    APIERROR(myTransaction->getNdbError());

  /* Second bound
   * ATTR1 > 5, <= 9
   * 6,7,8,9
   */
  low=5;
  high=9;

  bound.low_key=(char*)&low;
  bound.low_key_count=1;
  bound.low_inclusive=false;
  bound.high_key=(char*)&high;
  bound.high_key_count=1;
  bound.high_inclusive=true;
  bound.range_no=1;

  if (psop->setBound(pkeyIndexRecord, bound))
    APIERROR(myTransaction->getNdbError());

  if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
    APIERROR(myTransaction->getNdbError());


  RowData *prowData; // Ptr to point to our data

  int rc=0;

  while ((rc = psop->nextResult((const char**) &prowData,
                              true,
                              false)) == 0)
  {
    printf(" %2d    %2d    %2d    Range no : %2d\n",
           prowData->attr1,
           prowData->attr2,
           recAttrAttr3->u_32_value(),
           psop->get_range_no());
  }

  if (rc != 1)  APIERROR(myTransaction->getNdbError());

  psop->close(true);

  if(myTransaction->execute( NdbTransaction::Commit ) !=0)
    APIERROR(myTransaction->getNdbError());
```

```
  myNdb.closeTransaction(myTransaction);

  std::cout << "-------\n";
}


/*******************************************************
 * Read + Delete one tuple (the one with primary key 8) *
 *******************************************************/
static void do_read_and_delete(Ndb &myNdb)
{
  /* This procedure performs a single operation, single round
   * trip read and then delete of a tuple, specified by
   * primary key
   */
  std::cout << "Running do_read_and_delete (NdbRecord only)\n";

  NdbTransaction *myTransaction= myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  RowData row;
  row.attr1=8;
  row.attr2=0; // Don't care
  row.attr3=0; // Don't care

  /* We'll also read some extra columns while we're
   * reading + deleting
   */
  NdbOperation::OperationOptions options;
  NdbOperation::GetValueSpec extraGets[2];
  extraGets[0].column = pattr3Col;
  extraGets[0].appStorage = NULL;
  extraGets[0].recAttr = NULL;
  extraGets[1].column = NdbDictionary::Column::COMMIT_COUNT;
  extraGets[1].appStorage = NULL;
  extraGets[1].recAttr = NULL;

  options.optionsPresent= NdbOperation::OperationOptions::OO_GETVALUE;
  options.extraGetValues= &extraGets[0];
  options.numExtraGetValues= 2;

  unsigned char attrMask = (1<<attr2ColNum); // Only read Col2 into row

  const NdbOperation *pop=
    myTransaction->deleteTuple(pkeyColumnRecord, // Spec of key used
                               (char*) &row, // Key information
                               pallColsRecord, // Spec of columns to read
                               (char*) &row, // Row to read values into
                               &attrMask, // Cols to read as part of delete
                               &options,
                               sizeof(NdbOperation::OperationOptions));

  if (pop==NULL) APIERROR(myTransaction->getNdbError());

  if (myTransaction->execute(NdbTransaction::Commit) == -1)
    APIERROR(myTransaction->getNdbError());

  std::cout << "ATTR1 ATTR2 ATTR3 COMMITS" << std::endl;
  printf(" %2d    %2d    %2d    %2d\n",
         row.attr1,
         row.attr2,
         extraGets[0].recAttr->u_32_value(),
         extraGets[1].recAttr->u_32_value());

  myNdb.closeTransaction(myTransaction);

  std::cout << "-------\n";
}

/* Some handy consts for scan control */
static const int GOT_ROW= 0;
```

```
static const int NO_MORE_ROWS= 1;
static const int NEED_TO_FETCH_ROWS= 2;

/**********************************************
 * Read and update all tuples via table scan *
 **********************************************/
static void do_scan_update(Ndb &myNdb, ApiType accessType)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable=
                            myDict->getTable("api_recattr_vs_record");

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  std::cout << "Running do_scan_update\n";

  NdbTransaction *myTransaction=myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  NdbScanOperation *psop;
  NdbRecAttr *recAttrAttr1;
  NdbRecAttr *recAttrAttr2;
  NdbRecAttr *recAttrAttr3;

  switch (accessType)
  {
    case api_attr :
    {
      psop=myTransaction->getNdbScanOperation(myTable);

      if (psop == NULL) APIERROR(myTransaction->getNdbError());

      /* When we want to operate on the tuples returned from a
       * scan, we need to request the tuple's keyinfo is
       * returned, with SF_KeyInfo
       */
      if (psop->readTuples(NdbOperation::LM_Read,
                           NdbScanOperation::SF_KeyInfo) != 0)
        APIERROR (myTransaction->getNdbError());

      recAttrAttr1=psop->getValue("ATTR1");
      recAttrAttr2=psop->getValue("ATTR2");
      recAttrAttr3=psop->getValue("ATTR3");

      break;
    }
    case api_record :
    {
      NdbScanOperation::ScanOptions options;
      options.optionsPresent= NdbScanOperation::ScanOptions::SO_SCANFLAGS;
      options.scan_flags= NdbScanOperation::SF_KeyInfo;

      psop=myTransaction->scanTable(pallColsRecord,
                                    NdbOperation::LM_Read,
                                    NULL,  // mask - read all columns
                                    &options,
                                    sizeof(NdbScanOperation::ScanOptions));

      if (psop == NULL) APIERROR(myTransaction->getNdbError());

      break;
    }
  default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
  }

  if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
    APIERROR(myTransaction->getNdbError());
```

```
switch (accessType)
{
  case api_attr :
  {


    int result= NEED_TO_FETCH_ROWS;
    Uint32 processed= 0;

    while (result == NEED_TO_FETCH_ROWS)
    {
      bool fetch=true;
      while ((result = psop->nextResult(fetch)) == GOT_ROW)
      {
        fetch= false;
        Uint32 col2Value=recAttrAttr2->u_32_value();

        NdbOperation *op=psop->updateCurrentTuple();
        if (op==NULL)
          APIERROR(myTransaction->getNdbError());
        op->setValue("ATTR2", (10*col2Value));

        processed++;
      }
      if (result < 0)
        APIERROR(myTransaction->getNdbError());

      if (processed !=0)
      {
        // Need to execute

        if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
          APIERROR(myTransaction->getNdbError());
        processed=0;
      }
    }

    psop->close();

    break;
  }
  case api_record :
  {
    RowData *prowData; // Ptr to point to our data

    int result= NEED_TO_FETCH_ROWS;
    Uint32 processed=0;

    while (result == NEED_TO_FETCH_ROWS)
    {
      bool fetch= true;
      while ((result = psop->nextResult((const char**) &prowData,
                                        fetch, false)) == GOT_ROW)
      {
        fetch= false;

        /* Copy row into a stack variable */
        RowData r= *prowData;

        /* Modify attr2 */
        r.attr2*= 10;

        /* Update it */
        const NdbOperation *op = psop->updateCurrentTuple(myTransaction,
                                                          pallColsRecord,
                                                          (char*) &r);

        if (op==NULL)
          APIERROR(myTransaction->getNdbError());

        processed ++;
```

```
        }

        if (result < 0)
          APIERROR(myTransaction->getNdbError());


        if (processed !=0)
        {
          /* To get here, there are no more cached scan results,
           * and some row updates that we've not sent yet.
           * Send them before we try to get another batch, or
           * finish.
           */
          if (myTransaction->execute( NdbTransaction::NoCommit ) != 0)
            APIERROR(myTransaction->getNdbError());
          processed=0;
        }
      }

      psop->close(true);

      break;
    }
    default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
  }

  if(myTransaction->execute( NdbTransaction::Commit ) !=0)
    APIERROR(myTransaction->getNdbError());

  myNdb.closeTransaction(myTransaction);

  std::cout << "-------\n";
}

/***************************************************
 * Read all and delete some tuples via table scan *
 ***************************************************/
static void do_scan_delete(Ndb &myNdb, ApiType accessType)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable=
                              myDict->getTable("api_recattr_vs_record");

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  std::cout << "Running do_scan_delete\n";

  NdbTransaction *myTransaction=myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  NdbScanOperation *psop;
  NdbRecAttr *recAttrAttr1;

  /* Scan, retrieving first column.
   * Delete particular records, based on first column
   * Read third column as part of delete
   */
  switch (accessType)
  {
    case api_attr :
    {
      psop=myTransaction->getNdbScanOperation(myTable);

      if (psop == NULL) APIERROR(myTransaction->getNdbError());

      /* Need KeyInfo when performing scanning delete */
      if (psop->readTuples(NdbOperation::LM_Read,
```

```
                           NdbScanOperation::SF_KeyInfo) != 0)
        APIERROR (myTransaction->getNdbError());

      recAttrAttr1=psop->getValue("ATTR1");

      break;
    }
    case api_record :
    {


      NdbScanOperation::ScanOptions options;
      options.optionsPresent=NdbScanOperation::ScanOptions::SO_SCANFLAGS;
      /* Need KeyInfo when performing scanning delete */
      options.scan_flags=NdbScanOperation::SF_KeyInfo;

      psop=myTransaction->scanTable(pkeyColumnRecord,
                                    NdbOperation::LM_Read,
                                    NULL,  // mask
                                    &options,
                                    sizeof(NdbScanOperation::ScanOptions));

      if (psop == NULL) APIERROR(myTransaction->getNdbError());

      break;
    }
  default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
  }

  if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
    APIERROR(myTransaction->getNdbError());

  switch (accessType)
  {
    case api_attr :
    {
      int result= NEED_TO_FETCH_ROWS;
      Uint32 processed=0;

      while (result == NEED_TO_FETCH_ROWS)
      {
        bool fetch=true;
        while ((result = psop->nextResult(fetch)) == GOT_ROW)
        {
          fetch= false;
          Uint32 col1Value=recAttrAttr1->u_32_value();

          if (col1Value == 2)
          {
            /* Note : We cannot do a delete pre-read via
             * the NdbRecAttr interface.  We can only
             * delete here.
             */
            if (psop->deleteCurrentTuple())
              APIERROR(myTransaction->getNdbError());
            processed++;
          }
        }
        if (result < 0)
          APIERROR(myTransaction->getNdbError());

        if (processed !=0)
        {
          /* To get here, there are no more cached scan results,
           * and some row deletes that we've not sent yet.
           * Send them before we try to get another batch, or
           * finish.
           */
```

```
        if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
          APIERROR(myTransaction->getNdbError());
        processed=0;
      }
    }

    psop->close();

    break;
  }
  case api_record :
  {
    RowData *prowData; // Ptr to point to our data

    int result= NEED_TO_FETCH_ROWS;
    Uint32 processed=0;

    while (result == NEED_TO_FETCH_ROWS)
    {
      bool fetch=true;

      const NdbOperation* theDeleteOp;
      RowData readRow;
      NdbRecAttr* attr3;
      NdbRecAttr* commitCount;

      while ((result = psop->nextResult((const char**) &prowData,
                                        fetch,
                                        false)) == GOT_ROW)
      {
        fetch = false;

        /* Copy latest row to a stack local */
        RowData r;
        r= *prowData;

        if (r.attr1 == 2)
        {
          /* We're going to perform a read+delete on this
           * row.  We'll read attr1 and attr2 vian NDBRecord
           * and Attr3 and the commit count via extra
           * get values.
           */
          NdbOperation::OperationOptions options;
          NdbOperation::GetValueSpec extraGets[2];
          extraGets[0].column = pattr3Col;
          extraGets[0].appStorage = NULL;
          extraGets[0].recAttr = NULL;
          extraGets[1].column = NdbDictionary::Column::COMMIT_COUNT;
          extraGets[1].appStorage = NULL;
          extraGets[1].recAttr = NULL;

          options.optionsPresent= NdbOperation::OperationOptions::OO_GETVALUE;
          options.extraGetValues= &extraGets[0];
          options.numExtraGetValues= 2;

          // Read cols 1 + 2 vian NDBRecord
          unsigned char attrMask =
                  (1<<attr1ColNum) | (1<<attr2ColNum);

          theDeleteOp =
            psop->deleteCurrentTuple(myTransaction,
                                     pallColsRecord,
                                     (char*) &readRow,
                                     &attrMask,
                                     &options,
                                     sizeof(NdbOperation::OperationOptions)
                                    );

          if (theDeleteOp==NULL)
            APIERROR(myTransaction->getNdbError());
```

```
            /* Store extra Get RecAttrs */
            attr3= extraGets[0].recAttr;
            commitCount= extraGets[1].recAttr;

            processed ++;
          }
        }

        if (result < 0)
          APIERROR(myTransaction->getNdbError());


        if (processed !=0)
        {
          /* To get here, there are no more cached scan results,
           * and some row deletes that we've not sent yet.
           * Send them before we try to get another batch, or
           * finish.
           */
          if (myTransaction->execute( NdbTransaction::NoCommit ) != 0)
            APIERROR(myTransaction->getNdbError());
          processed=0;

          // Let's look at the data just read
          printf("Deleted data\n");
          printf("ATTR1  ATTR2  ATTR3 COMMITS\n");
          printf("  %2d    %2d    %2d    %2d\n",
                 readRow.attr1,
                 readRow.attr2,
                 attr3->u_32_value(),
                 commitCount->u_32_value());
        }
      }

      psop->close(true);

      break;
    }
    default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
  }

  if(myTransaction->execute( NdbTransaction::Commit ) !=0)
    APIERROR(myTransaction->getNdbError());

  myNdb.closeTransaction(myTransaction);

  std::cout << "-------\n";
}



/************************************************************
 * Read all tuples via scan, reread one with lock takeover *
 ************************************************************/
static void do_scan_lock_reread(Ndb &myNdb, ApiType accessType)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable=
                              myDict->getTable("api_recattr_vs_record");

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  std::cout << "Running do_scan_lock_reread\n";

  NdbTransaction *myTransaction=myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());
```

```
NdbScanOperation *psop;
NdbRecAttr *recAttrAttr1;

switch (accessType)
{
  case api_attr :
  {
    psop=myTransaction->getNdbScanOperation(myTable);

    if (psop == NULL) APIERROR(myTransaction->getNdbError());

    /* Need KeyInfo for lock takeover */
    if (psop->readTuples(NdbOperation::LM_Read,
                         NdbScanOperation::SF_KeyInfo) != 0)
      APIERROR (myTransaction->getNdbError());

    recAttrAttr1=psop->getValue("ATTR1");

    break;
  }
  case api_record :
  {
    NdbScanOperation::ScanOptions options;
    options.optionsPresent= NdbScanOperation::ScanOptions::SO_SCANFLAGS;
    /* Need KeyInfo for lock takeover */
    options.scan_flags= NdbScanOperation::SF_KeyInfo;

    psop=myTransaction->scanTable(pkeyColumnRecord,
                                  NdbOperation::LM_Read,
                                  NULL,  // mask
                                  &options,
                                  sizeof(NdbScanOperation::ScanOptions));

    if (psop == NULL) APIERROR(myTransaction->getNdbError());

    break;
  }
default :
  {
    std::cout << "Bad branch : " << accessType << "\n";
    exit(-1);
  }
}

if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
  APIERROR(myTransaction->getNdbError());

switch (accessType)
{
  case api_attr :
  {
    int result= NEED_TO_FETCH_ROWS;
    Uint32 processed=0;
    NdbRecAttr *attr1, *attr2, *attr3, *commitCount;

    while (result == NEED_TO_FETCH_ROWS)
    {
      bool fetch=true;
      while ((result = psop->nextResult(fetch)) == GOT_ROW)
      {
        fetch= false;
        Uint32 col1Value=recAttrAttr1->u_32_value();

        if (col1Value == 9)
        {
          /* Let's read the rest of the info for it with
           * a separate operation
           */
          NdbOperation *op= psop->lockCurrentTuple();

          if (op==NULL)
            APIERROR(myTransaction->getNdbError());
```

```
          attr1=op->getValue("ATTR1");
          attr2=op->getValue("ATTR2");
          attr3=op->getValue("ATTR3");
          commitCount=op->getValue(NdbDictionary::Column::COMMIT_COUNT);
          processed++;
        }
      }
      if (result < 0)
        APIERROR(myTransaction->getNdbError());

      if (processed !=0)
      {
        // Need to execute

        if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
          APIERROR(myTransaction->getNdbError());
        processed=0;

        // Let's look at the whole row...
        printf("Locked and re-read data:\n");
        printf("ATTR1  ATTR2  ATTR3 COMMITS\n");
        printf("  %2d    %2d    %2d    %2d\n",
               attr1->u_32_value(),
               attr2->u_32_value(),
               attr3->u_32_value(),
               commitCount->u_32_value());
      }
    }

    psop->close();

    break;
  }
  case api_record :
  {
    RowData *prowData; // Ptr to point to our data

    int result= NEED_TO_FETCH_ROWS;
    Uint32 processed=0;
    RowData rereadData;
    NdbRecAttr *attr3, *commitCount;

    while (result == NEED_TO_FETCH_ROWS)
    {
      bool fetch=true;
      while ((result = psop->nextResult((const char**) &prowData,
                                        fetch,
                                        false)) == GOT_ROW)
      {
        fetch = false;

        /* Copy row to stack local */
        RowData r;
        r=*prowData;

        if (r.attr1 == 9)
        {
          /* Perform extra read of this row via lockCurrentTuple
           * Read all columns using NdbRecord for attr1 + attr2,
           * and extra get values for attr3 and the commit count
           */
          NdbOperation::OperationOptions options;
          NdbOperation::GetValueSpec extraGets[2];
          extraGets[0].column = pattr3Col;
          extraGets[0].appStorage = NULL;
          extraGets[0].recAttr = NULL;
          extraGets[1].column = NdbDictionary::Column::COMMIT_COUNT;
          extraGets[1].appStorage = NULL;
          extraGets[1].recAttr = NULL;

          options.optionsPresent=NdbOperation::OperationOptions::OO_GETVALUE;
          options.extraGetValues=&extraGets[0];
```

```
            options.numExtraGetValues=2;

            // Read cols 1 + 2 vian NDBRecord
            unsigned char attrMask =
                        (1<<attr1ColNum) | (1<<attr2ColNum);

            const NdbOperation *lockOp =
                psop->lockCurrentTuple(myTransaction,
                                          pallColsRecord,
                                          (char *) &rereadData,
                                          &attrMask,
                                          &options,
                                          sizeof(NdbOperation::OperationOptions)
                                         );
            if (lockOp == NULL)
              APIERROR(myTransaction->getNdbError());

            attr3= extraGets[0].recAttr;
            commitCount= extraGets[1].recAttr;

            processed++;
          }
        }

        if (result < 0)
          APIERROR(myTransaction->getNdbError());


        if (processed !=0)
        {
          // Need to execute

          if (myTransaction->execute( NdbTransaction::NoCommit ) != 0)
            APIERROR(myTransaction->getNdbError());
          processed=0;

          // Let's look at the whole row...
          printf("Locked and re-read data:\n");
          printf("ATTR1  ATTR2  ATTR3 COMMITS\n");
          printf("  %2d    %2d    %2d    %2d\n",
                 rereadData.attr1,
                 rereadData.attr2,
                 attr3->u_32_value(),
                 commitCount->u_32_value());

        }
      }

      psop->close(true);

      break;
    }
    default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
  }

  if(myTransaction->execute( NdbTransaction::Commit ) !=0)
    APIERROR(myTransaction->getNdbError());

  myNdb.closeTransaction(myTransaction);

  std::cout << "-------\n";
}

/*****************************************************************
 * Read all tuples via primary key, using only extra getValues *
 *****************************************************************/
static void do_all_extras_read(Ndb &myNdb)
{
```

```
std::cout << "Running do_all_extras_read(NdbRecord only)\n";
std::cout << "ATTR1 ATTR2 ATTR3 COMMIT_COUNT" << std::endl;

for (int i = 0; i < 10; i++) {
  NdbTransaction *myTransaction= myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  RowData rowData;
  NdbRecAttr *myRecAttr1, *myRecAttr2, *myRecAttr3, *myRecAttrCC;

  /* We read nothing vian NDBRecord, and everything via
   * 'extra' reads
   */
  NdbOperation::GetValueSpec extraCols[4];

  extraCols[0].column=pattr1Col;
  extraCols[0].appStorage=NULL;
  extraCols[0].recAttr=NULL;

  extraCols[1].column=pattr2Col;
  extraCols[1].appStorage=NULL;
  extraCols[1].recAttr=NULL;

  extraCols[2].column=pattr3Col;
  extraCols[2].appStorage=NULL;
  extraCols[2].recAttr=NULL;

  extraCols[3].column=NdbDictionary::Column::COMMIT_COUNT;
  extraCols[3].appStorage=NULL;
  extraCols[3].recAttr=NULL;

  NdbOperation::OperationOptions opts;
  opts.optionsPresent = NdbOperation::OperationOptions::OO_GETVALUE;

  opts.extraGetValues=&extraCols[0];
  opts.numExtraGetValues=4;

  unsigned char attrMask= 0; // No row results required.

  // Set PK search criteria
  rowData.attr1= i;

  const NdbOperation *pop=
    myTransaction->readTuple(pkeyColumnRecord,
                             (char*) &rowData,
                             pkeyColumnRecord,
                             NULL, // null result row
                             NdbOperation::LM_Read,
                             &attrMask,
                             &opts);
  if (pop==NULL) APIERROR(myTransaction->getNdbError());

  myRecAttr1=extraCols[0].recAttr;
  myRecAttr2=extraCols[1].recAttr;
  myRecAttr3=extraCols[2].recAttr;
  myRecAttrCC=extraCols[3].recAttr;

  if (myRecAttr1 == NULL) APIERROR(myTransaction->getNdbError());
  if (myRecAttr2 == NULL) APIERROR(myTransaction->getNdbError());
  if (myRecAttr3 == NULL) APIERROR(myTransaction->getNdbError());
  if (myRecAttrCC == NULL) APIERROR(myTransaction->getNdbError());

  if(myTransaction->execute( NdbTransaction::Commit ) == -1)
    APIERROR(myTransaction->getNdbError());

  bool deleted= (myTransaction->getNdbError().classification ==
                 NdbError::NoDataFound);
  if (deleted)
    printf("Detected that deleted tuple %d doesn't exist!\n", i);
  else
  {
    printf(" %2d    %2d    %2d    %d\n",
```

```
             myRecAttr1->u_32_value(),
             myRecAttr2->u_32_value(),
             myRecAttr3->u_32_value(),
             myRecAttrCC->u_32_value()
             );
    }

    myNdb.closeTransaction(myTransaction);
  }

  std::cout << "-------\n";
}


/*****************************************************************
 * Read and print some tuples via bounded scan of secondary index *
 *****************************************************************/
static void do_secondary_indexScan(Ndb &myNdb, ApiType accessType)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Index *mySIndex=
              myDict->getIndex("MYINDEXNAME", "api_recattr_vs_record");

  std::cout << "Running do_secondary_indexScan\n";
  std::cout << "ATTR1 ATTR2 ATTR3" << std::endl;

  NdbTransaction *myTransaction=myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  NdbIndexScanOperation *psop;
  NdbRecAttr *recAttrAttr1;
  NdbRecAttr *recAttrAttr2;
  NdbRecAttr *recAttrAttr3;

  Uint32 scanFlags =
    NdbScanOperation::SF_OrderBy |
    NdbScanOperation::SF_Descending |
    NdbScanOperation::SF_MultiRange |
    NdbScanOperation::SF_ReadRangeNo;

  switch (accessType)
  {
    case api_attr :
    {
      psop=myTransaction->getNdbIndexScanOperation(mySIndex);

      if (psop == NULL) APIERROR(myTransaction->getNdbError());

      if (psop->readTuples(NdbOperation::LM_Read,
                           scanFlags,
                           (Uint32) 0,          // batch
                           (Uint32) 0) != 0)    // parallel
        APIERROR (myTransaction->getNdbError());

      /* Bounds :
       * > ATTR3=6
       * < ATTR3=42
       */
      Uint32 low=6;
      Uint32 high=42;

      if (psop->setBound("ATTR3",
                        NdbIndexScanOperation::BoundLT, (char*)&low))
        APIERROR(psop->getNdbError());

      if (psop->setBound("ATTR3",
                        NdbIndexScanOperation::BoundGT, (char*)&high))
        APIERROR(psop->getNdbError());

      recAttrAttr1=psop->getValue("ATTR1");
      recAttrAttr2=psop->getValue("ATTR2");
      recAttrAttr3=psop->getValue("ATTR3");
```

```
      break;
    }
    case api_record :
    {

      NdbScanOperation::ScanOptions options;
      options.optionsPresent=NdbScanOperation::ScanOptions::SO_SCANFLAGS;
      options.scan_flags=scanFlags;

      psop=myTransaction->scanIndex(psecondaryIndexRecord,
                                    pallColsRecord,
                                    NdbOperation::LM_Read,
                                    NULL, // mask
                                    NULL, // bound
                                    &options,
                                    sizeof(NdbScanOperation::ScanOptions));

      if (psop == NULL) APIERROR(myTransaction->getNdbError());

      /* Bounds :
       * > ATTR3=6
       * < ATTR3=42
       */
      Uint32 low=6;
      Uint32 high=42;

      NdbIndexScanOperation::IndexBound bound;
      bound.low_key=(char*)&low;
      bound.low_key_count=1;
      bound.low_inclusive=false;
      bound.high_key=(char*)&high;
      bound.high_key_count=1;
      bound.high_inclusive=false;
      bound.range_no=0;

      if (psop->setBound(psecondaryIndexRecord, bound))
        APIERROR(myTransaction->getNdbError());

      break;
    }
  default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
  }

  if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
    APIERROR(myTransaction->getNdbError());

  // Check rc anyway
  if (myTransaction->getNdbError().status != NdbError::Success)
    APIERROR(myTransaction->getNdbError());

  switch (accessType)
  {
    case api_attr :
    {
      while (psop->nextResult(true) == 0)
      {
        printf(" %2d    %2d    %2d    Range no : %2d\n",
               recAttrAttr1->u_32_value(),
               recAttrAttr2->u_32_value(),
               recAttrAttr3->u_32_value(),
               psop->get_range_no());
      }

      psop->close();

      break;
    }
```

```
    case api_record :
    {
      RowData *prowData; // Ptr to point to our data

      int rc=0;

      while ((rc = psop->nextResult((const char**) &prowData,
                                    true,
                                    false)) == 0)
      {
        // printf(" PTR : %d\n", (int) prowData);
        printf(" %2d    %2d    %2d    Range no : %2d\n",
               prowData->attr1,
               prowData->attr2,
               prowData->attr3,
               psop->get_range_no());
      }

      if (rc != 1)  APIERROR(myTransaction->getNdbError());

      psop->close(true);

      break;
    }
    default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
  }

  if(myTransaction->execute( NdbTransaction::Commit ) !=0)
    APIERROR(myTransaction->getNdbError());

  myNdb.closeTransaction(myTransaction);

  std::cout << "-------\n";
}


/************************************************************************
 * Index scan to read tuples from secondary index using equality bound *
 ***********************************************************************/
static void do_secondary_indexScanEqual(Ndb &myNdb, ApiType accessType)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Index *mySIndex=
                myDict->getIndex("MYINDEXNAME", "api_recattr_vs_record");

  std::cout << "Running do_secondary_indexScanEqual\n";
  std::cout << "ATTR1 ATTR2 ATTR3" << std::endl;

  NdbTransaction *myTransaction=myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  NdbIndexScanOperation *psop;
  NdbRecAttr *recAttrAttr1;
  NdbRecAttr *recAttrAttr2;
  NdbRecAttr *recAttrAttr3;

  Uint32 scanFlags = NdbScanOperation::SF_OrderBy;

  Uint32 attr3Eq= 44;

  switch (accessType)
  {
    case api_attr :
    {
      psop=myTransaction->getNdbIndexScanOperation(mySIndex);

      if (psop == NULL) APIERROR(myTransaction->getNdbError());
```

```
    if (psop->readTuples(NdbOperation::LM_Read,
                         scanFlags,
                         (Uint32) 0,          // batch
                         (Uint32) 0) != 0)    // parallel
      APIERROR (myTransaction->getNdbError());

    if (psop->setBound("ATTR3",
                      NdbIndexScanOperation::BoundEQ, (char*)&attr3Eq))
      APIERROR(myTransaction->getNdbError());

    recAttrAttr1=psop->getValue("ATTR1");
    recAttrAttr2=psop->getValue("ATTR2");
    recAttrAttr3=psop->getValue("ATTR3");

    break;
  }
  case api_record :
  {

    NdbScanOperation::ScanOptions options;
    options.optionsPresent= NdbScanOperation::ScanOptions::SO_SCANFLAGS;
    options.scan_flags=scanFlags;

    psop=myTransaction->scanIndex(psecondaryIndexRecord,
                                  pallColsRecord, // Read all table rows back
                                  NdbOperation::LM_Read,
                                  NULL, // mask
                                  NULL, // bound specified below
                                  &options,
                                  sizeof(NdbScanOperation::ScanOptions));

    if (psop == NULL) APIERROR(myTransaction->getNdbError());

    /* Set equality bound via two inclusive bounds */
    NdbIndexScanOperation::IndexBound bound;
    bound.low_key= (char*)&attr3Eq;
    bound.low_key_count= 1;
    bound.low_inclusive= true;
    bound.high_key= (char*)&attr3Eq;
    bound.high_key_count= 1;
    bound.high_inclusive= true;
    bound.range_no= 0;

    if (psop->setBound(psecondaryIndexRecord, bound))
      APIERROR(myTransaction->getNdbError());

    break;
  }
default :
  {
    std::cout << "Bad branch : " << accessType << "\n";
    exit(-1);
  }
}

if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
  APIERROR(myTransaction->getNdbError());

// Check rc anyway
if (myTransaction->getNdbError().status != NdbError::Success)
  APIERROR(myTransaction->getNdbError());

switch (accessType)
{
  case api_attr :
  {
    int res;

    while ((res= psop->nextResult(true)) == GOT_ROW)
    {
      printf(" %2d    %2d    %2d\n",
             recAttrAttr1->u_32_value(),
```

```
                recAttrAttr2->u_32_value(),
                recAttrAttr3->u_32_value());
      }

      if (res != NO_MORE_ROWS)
        APIERROR(psop->getNdbError());

      psop->close();

      break;
    }
    case api_record :
    {
      RowData *prowData; // Ptr to point to our data

      int rc=0;

      while ((rc = psop->nextResult((const char**) &prowData,
                                    true,   // fetch
                                    false)) // forceSend
             == GOT_ROW)
      {
        printf(" %2d    %2d    %2d\n",
                prowData->attr1,
                prowData->attr2,
                prowData->attr3);
      }

      if (rc != NO_MORE_ROWS)
        APIERROR(myTransaction->getNdbError());

      psop->close(true);

      break;
    }
    default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
  }

  if(myTransaction->execute( NdbTransaction::Commit ) !=0)
    APIERROR(myTransaction->getNdbError());

  myNdb.closeTransaction(myTransaction);

  std::cout << "-------\n";
}


/**********************
 * Interpreted update *
 **********************/
static void do_interpreted_update(Ndb &myNdb, ApiType accessType)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();

  const NdbDictionary::Table *myTable=
                            myDict->getTable("api_recattr_vs_record");

  const NdbDictionary::Index *myPIndex=
                     myDict->getIndex("PRIMARY", "api_recattr_vs_record");

  std::cout << "Running do_interpreted_update\n";

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());
  if (myPIndex == NULL)
    APIERROR(myDict->getNdbError());

  std::cout << "ATTR1 ATTR2 ATTR3" << std::endl;
```

```
NdbTransaction *myTransaction=myNdb.startTransaction();
if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

NdbRecAttr *recAttrAttr1;
NdbRecAttr *recAttrAttr2;
NdbRecAttr *recAttrAttr3;
NdbRecAttr *recAttrAttr11;
NdbRecAttr *recAttrAttr12;
NdbRecAttr *recAttrAttr13;
RowData rowData;
RowData rowData2;

/* Register aliases */
const Uint32 R1=1, R2=2, R3=3, R4=4, R5=5, R6=6;

switch (accessType)
{
  case api_attr :
  {
    NdbOperation *pop;
    pop=myTransaction->getNdbOperation(myTable);

    if (pop == NULL) APIERROR(myTransaction->getNdbError());

    if (pop->interpretedUpdateTuple())
      APIERROR (pop->getNdbError());

    /* Interpreted update on row where ATTR1 == 4 */
    if (pop->equal("ATTR1", 4) != 0)
      APIERROR (pop->getNdbError());

    /* First, read the values of all attributes in the normal way */
    recAttrAttr1=pop->getValue("ATTR1");
    recAttrAttr2=pop->getValue("ATTR2");
    recAttrAttr3=pop->getValue("ATTR3");

    /* Now define interpreted program which will run after the
     * values have been read
     * This program is rather tortuous and doesn't achieve much other
     * than demonstrating control flow, register and some column
     * operations
     */
    // R5= 3
    if (pop->load_const_u32(R5, 3) != 0)
      APIERROR (pop->getNdbError());

    // R1= *ATTR1; R2= *ATTR2; R3= *ATTR3
    if (pop->read_attr("ATTR1", R1) != 0)
      APIERROR (pop->getNdbError());
    if (pop->read_attr("ATTR2", R2) != 0)
      APIERROR (pop->getNdbError());
    if (pop->read_attr("ATTR3", R3) != 0)
      APIERROR (pop->getNdbError());

    // R3= R3-R5
    if (pop->sub_reg(R3, R5, R3) != 0)
      APIERROR (pop->getNdbError());

    // R2= R1+R2
    if (pop->add_reg(R1, R2, R2) != 0)
      APIERROR (pop->getNdbError());

    // *ATTR2= R2
    if (pop->write_attr("ATTR2", R2) != 0)
      APIERROR (pop->getNdbError());

    // *ATTR3= R3
    if (pop->write_attr("ATTR3", R3) != 0)
      APIERROR (pop->getNdbError());

    // *ATTR3 = *ATTR3 - 30
```

```
    if (pop->subValue("ATTR3", (Uint32)30) != 0)
      APIERROR (pop->getNdbError());

    Uint32 comparisonValue= 10;

    // if *ATTR3 > comparisonValue, goto Label 0
    if (pop->branch_col_lt(pattr3Col->getColumnNo(),
                           &comparisonValue,
                           sizeof(Uint32),
                           false,
                           0) != 0)
      APIERROR (pop->getNdbError());

    // assert(false)
    // Fail the operation with error 627 if we get here.
    if (pop->interpret_exit_nok(627) != 0)
      APIERROR (pop->getNdbError());

    // Label 0
    if (pop->def_label(0) != 0)
      APIERROR (pop->getNdbError());

    Uint32 comparisonValue2= 344;

    // if *ATTR2 == comparisonValue, goto Label 1
    if (pop->branch_col_eq(pattr2Col->getColumnNo(),
                           &comparisonValue2,
                           sizeof(Uint32),
                           false,
                           1) != 0)
      APIERROR (pop->getNdbError());

    // assert(false)
    // Fail the operation with error 628 if we get here
    if (pop->interpret_exit_nok(628) != 0)
      APIERROR (pop->getNdbError());

    // Label 1
    if (pop->def_label(1) != 1)
      APIERROR (pop->getNdbError());

    // Optional infinite loop
    //if (pop->branch_label(0) != 0)
    //  APIERROR (pop->getNdbError());

    // R1 = 10
    if (pop->load_const_u32(R1, 10) != 0)
      APIERROR (pop->getNdbError());

    // R3 = 2
    if (pop->load_const_u32(R3, 2) != 0)
      APIERROR (pop->getNdbError());

    // Now call subroutine 0
    if (pop->call_sub(0) != 0)
      APIERROR (pop->getNdbError());

    // *ATTR2= R2
    if (pop->write_attr("ATTR2", R2) != 0)
      APIERROR (pop->getNdbError());

    // Return ok, we'll move onto an update.
    if (pop->interpret_exit_ok() != 0)
      APIERROR (pop->getNdbError());

    /* Define a final read of the columns after the update */
    recAttrAttr11= pop->getValue("ATTR1");
    recAttrAttr12= pop->getValue("ATTR2");
    recAttrAttr13= pop->getValue("ATTR3");

    // Define any subroutines called by the 'main' program
    // Subroutine 0
```

```
      if (pop->def_subroutine(0) != 0)
        APIERROR (pop->getNdbError());

      // R4= 1
      if (pop->load_const_u32(R4, 1) != 0)
        APIERROR (pop->getNdbError());

      // Label 2
      if (pop->def_label(2) != 2)
        APIERROR (pop->getNdbError());

      // R3= R3-R4
      if (pop->sub_reg(R3, R4, R3) != 0)
        APIERROR (pop->getNdbError());

      // R2= R2 + R1
      if (pop->add_reg(R2, R1, R2) != 0)
        APIERROR (pop->getNdbError());

      // Optional infinite loop
      // if (pop->branch_label(2) != 0)
      //  APIERROR (pop->getNdbError());

      // Loop, subtracting 1 from R4 until R4 < 1
      if (pop->branch_ge(R4, R3, 2) != 0)
        APIERROR (pop->getNdbError());

      // Jump to label 3
      if (pop->branch_label(3) != 0)
        APIERROR (pop->getNdbError());

      // assert(false)
      // Fail operation with error 629
      if (pop->interpret_exit_nok(629) != 0)
        APIERROR (pop->getNdbError());

      // Label 3
      if (pop->def_label(3) != 3)
        APIERROR (pop->getNdbError());

      // Nested subroutine call to sub 2
      if (pop->call_sub(2) != 0)
        APIERROR (pop->getNdbError());

      // Return from subroutine 0
      if (pop->ret_sub() !=0)
        APIERROR (pop->getNdbError());

      // Subroutine 1
      if (pop->def_subroutine(1) != 1)
        APIERROR (pop->getNdbError());

      // R6= R1+R2
      if (pop->add_reg(R1, R2, R6) != 0)
        APIERROR (pop->getNdbError());

      // Return from subrouine 1
      if (pop->ret_sub() !=0)
        APIERROR (pop->getNdbError());

      // Subroutine 2
      if (pop->def_subroutine(2) != 2)
        APIERROR (pop->getNdbError());

      // Call backward to subroutine 1
      if (pop->call_sub(1) != 0)
        APIERROR (pop->getNdbError());

      // Return from subroutine 2
      if (pop->ret_sub() !=0)
        APIERROR (pop->getNdbError());
```

```
      break;
    }
    case api_record :
    {
      const NdbOperation *pop;
      rowData.attr1= 4;

      /* NdbRecord does not support an updateTuple pre-read or post-read, so
       * we use separate operations for these.
       * Note that this assumes that a operations are executed in
       * the order they are defined by NDBAPI, which is not guaranteed.  To
       * ensure execution order, the application should perform a NoCommit
       * execute between operations.
       */

      const NdbOperation *op0= myTransaction->readTuple(pkeyColumnRecord,
                                                        (char*) &rowData,
                                                        pallColsRecord,
                                                        (char*) &rowData);
      if (op0 == NULL)
        APIERROR (myTransaction->getNdbError());

      /* Allocate some space to define an Interpreted program */
      const Uint32 numWords= 64;
      Uint32 space[numWords];

      NdbInterpretedCode stackCode(myTable,
                                   &space[0],
                                   numWords);

      NdbInterpretedCode *code= &stackCode;

      /* Similar program as above, with tortuous control flow and little
       * purpose.  Note that for NdbInterpretedCode, some instruction
       * arguments are in different orders
       */

      // R5= 3
      if (code->load_const_u32(R5, 3) != 0)
        APIERROR(code->getNdbError());

      // R1= *ATTR1; R2= *ATTR2; R3= *ATTR3
      if (code->read_attr(R1, pattr1Col) != 0)
        APIERROR (code->getNdbError());
      if (code->read_attr(R2, pattr2Col) != 0)
        APIERROR (code->getNdbError());
      if (code->read_attr(R3, pattr3Col) != 0)
        APIERROR (code->getNdbError());

      // R3= R3-R5
      if (code->sub_reg(R3, R3, R5) != 0)
        APIERROR (code->getNdbError());

      // R2= R1+R2
      if (code->add_reg(R2, R1, R2) != 0)
        APIERROR (code->getNdbError());

      // *ATTR2= R2
      if (code->write_attr(pattr2Col, R2) != 0)
        APIERROR (code->getNdbError());

      // *ATTR3= R3
      if (code->write_attr(pattr3Col, R3) != 0)
        APIERROR (code->getNdbError());

      // *ATTR3 = *ATTR3 - 30
      if (code->sub_val(pattr3Col->getColumnNo(), (Uint32)30) != 0)
        APIERROR (code->getNdbError());

      Uint32 comparisonValue= 10;

      // if comparisonValue < *ATTR3, goto Label 0
```

```
    if (code->branch_col_lt(&comparisonValue,
                            sizeof(Uint32),
                            pattr3Col->getColumnNo(),
                            0) != 0)
      APIERROR (code->getNdbError());

    // assert(false)
    // Fail operation with error 627
    if (code->interpret_exit_nok(627) != 0)
      APIERROR (code->getNdbError());

    // Label 0
    if (code->def_label(0) != 0)
      APIERROR (code->getNdbError());

    Uint32 comparisonValue2= 344;

    // if *ATTR2 == comparisonValue, goto Label 1
    if (code->branch_col_eq(&comparisonValue2,
                            sizeof(Uint32),
                            pattr2Col->getColumnNo(),
                            1) != 0)
      APIERROR (code->getNdbError());

    // assert(false)
    // Fail operation with error 628
    if (code->interpret_exit_nok(628) != 0)
      APIERROR (code->getNdbError());

    // Label 1
    if (code->def_label(1) != 0)
      APIERROR (code->getNdbError());

    // R1= 10
    if (code->load_const_u32(R1, 10) != 0)
      APIERROR (code->getNdbError());

    // R3= 2
    if (code->load_const_u32(R3, 2) != 0)
      APIERROR (code->getNdbError());

    // Call subroutine 0 to effect
    // R2 = R2 + (R1*R3)
    if (code->call_sub(0) != 0)
      APIERROR (code->getNdbError());

    // *ATTR2= R2
    if (code->write_attr(pattr2Col, R2) != 0)
      APIERROR (code->getNdbError());

    // Return ok
    if (code->interpret_exit_ok() != 0)
      APIERROR (code->getNdbError());

    // Subroutine 0
    if (code->def_sub(0) != 0)
      APIERROR (code->getNdbError());

    // R4= 1
    if (code->load_const_u32(R4, 1) != 0)
      APIERROR (code->getNdbError());

    // Label 2
    if (code->def_label(2) != 0)
      APIERROR (code->getNdbError());

    // R3= R3-R4
    if (code->sub_reg(R3, R3, R4) != 0)
      APIERROR (code->getNdbError());

    // R2= R2+R1
    if (code->add_reg(R2, R2, R1) != 0)
```

```
      APIERROR (code->getNdbError());

    // Loop, subtracting 1 from R4 until R4>1
    if (code->branch_ge(R3, R4, 2) != 0)
      APIERROR (code->getNdbError());

    // Jump to label 3
    if (code->branch_label(3) != 0)
      APIERROR (code->getNdbError());

    // Fail operation with error 629
    if (code->interpret_exit_nok(629) != 0)
      APIERROR (code->getNdbError());

    // Label 3
    if (code->def_label(3) != 0)
      APIERROR (code->getNdbError());

    // Call sub 2
    if (code->call_sub(2) != 0)
      APIERROR (code->getNdbError());

    // Return from sub 0
    if (code->ret_sub() != 0)
      APIERROR (code->getNdbError());

    // Subroutine 1
    if (code->def_sub(1) != 0)
      APIERROR (code->getNdbError());

    // R6= R1+R2
    if (code->add_reg(R6, R1, R2) != 0)
      APIERROR (code->getNdbError());

    // Return from subroutine 1
    if (code->ret_sub() !=0)
      APIERROR (code->getNdbError());

    // Subroutine 2
    if (code->def_sub(2) != 0)
      APIERROR (code->getNdbError());

    // Call backward to subroutine 1
    if (code->call_sub(1) != 0)
      APIERROR (code->getNdbError());

    // Return from subroutine 2
    if (code->ret_sub() !=0)
      APIERROR (code->getNdbError());

    /* Finalise code object
     * This step is essential for NdbInterpretedCode objects
     * and must be done before they can be used.
     */
    if (code->finalise() !=0)
      APIERROR (code->getNdbError());

    /* Time to define the update operation to use the
     * InterpretedCode object.  The same finalised object
     * could be used with multiple operations or even
     * multiple threads
     */
    NdbOperation::OperationOptions oo;
    oo.optionsPresent=
      NdbOperation::OperationOptions::OO_INTERPRETED;
    oo.interpretedCode= code;

    unsigned char mask= 0;

    pop= myTransaction->updateTuple(pkeyColumnRecord,
                                    (char*) &rowData,
                                    pallColsRecord,
```

```
                                    (char*) &rowData,
                                    (const unsigned char *) &mask,
                                              // mask - update nothing
                                    &oo,
                                    sizeof(NdbOperation::OperationOptions));
      if (pop == NULL)
        APIERROR (myTransaction->getNdbError());

      // NoCommit execute so we can read the 'after' data.
      if (myTransaction->execute( NdbTransaction::NoCommit ) != 0)
        APIERROR(myTransaction->getNdbError());

      /* Second read op as we can't currently do a 'read after
       * 'interpreted code' read as part of NdbRecord.
       * We are assuming that the order of op definition == order
       * of execution on a single row, which is not guaranteed.
       */
      const NdbOperation *pop2=
        myTransaction->readTuple(pkeyColumnRecord,
                                 (char*) &rowData,
                                 pallColsRecord,
                                 (char*) &rowData2);
      if (pop2 == NULL)
        APIERROR (myTransaction->getNdbError());

      break;
    }
  default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
  }

  if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
    APIERROR(myTransaction->getNdbError());

  // Check return code
  if (myTransaction->getNdbError().status != NdbError::Success)
    APIERROR(myTransaction->getNdbError());

  switch (accessType)
  {
    case api_attr :
    {
      printf(" %2d    %2d    %2d  Before\n"
             " %2d    %2d    %2d  After\n",
             recAttrAttr1->u_32_value(),
             recAttrAttr2->u_32_value(),
             recAttrAttr3->u_32_value(),
             recAttrAttr11->u_32_value(),
             recAttrAttr12->u_32_value(),
             recAttrAttr13->u_32_value());
      break;
    }

    case api_record :
    {
      printf(" %2d    %2d    %2d  Before\n"
             " %2d    %2d    %2d  After\n",
             rowData.attr1,
             rowData.attr2,
             rowData.attr3,
             rowData2.attr1,
             rowData2.attr2,
             rowData2.attr3);
      break;
    }
    default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
```

```
    }
  }

  if(myTransaction->execute( NdbTransaction::Commit ) !=0)
    APIERROR(myTransaction->getNdbError());

  myNdb.closeTransaction(myTransaction);

  std::cout << "-------\n";
}


/*******************************************************
 * Read and print selected rows with interpreted code *
 *******************************************************/
static void do_interpreted_scan(Ndb &myNdb, ApiType accessType)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();
  const NdbDictionary::Table *myTable=
                              myDict->getTable("api_recattr_vs_record");

  std::cout << "Running do_interpreted_scan\n";

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  std::cout << "ATTR1 ATTR2 ATTR3" << std::endl;

  NdbTransaction *myTransaction=myNdb.startTransaction();
  if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

  NdbScanOperation *psop;
  NdbRecAttr *recAttrAttr1;
  NdbRecAttr *recAttrAttr2;
  NdbRecAttr *recAttrAttr3;

  /* Create some space on the stack for the program */
  const Uint32 numWords= 64;
  Uint32 space[numWords];

  NdbInterpretedCode stackCode(myTable,
                               &space[0],
                               numWords);

  NdbInterpretedCode *code= &stackCode;

  /* RecAttr and NdbRecord scans both use NdbInterpretedCode
   * Let's define a small scan filter of sorts
   */
  Uint32 comparisonValue= 10;

  // Return rows where 10 > ATTR3 (ATTR3 <10)
  if (code->branch_col_gt(&comparisonValue,
                          sizeof(Uint32),
                          pattr3Col->getColumnNo(),
                          0) != 0)
    APIERROR (myTransaction->getNdbError());

  /* If we get here then we don't return this row */
  if (code->interpret_exit_nok() != 0)
    APIERROR (myTransaction->getNdbError());

  /* Label 0 */
  if (code->def_label(0) != 0)
    APIERROR (myTransaction->getNdbError());

  /* Return this row */
  if (code->interpret_exit_ok() != 0)
    APIERROR (myTransaction->getNdbError());

  /* Finalise the Interpreted Program */
  if (code->finalise() != 0)
```

```
    APIERROR (myTransaction->getNdbError());

  switch (accessType)
  {
    case api_attr :
    {
      psop=myTransaction->getNdbScanOperation(myTable);

      if (psop == NULL)
        APIERROR(myTransaction->getNdbError());

      if (psop->readTuples(NdbOperation::LM_Read) != 0)
        APIERROR (myTransaction->getNdbError());

      if (psop->setInterpretedCode(code) != 0)
        APIERROR (myTransaction->getNdbError());

      recAttrAttr1=psop->getValue("ATTR1");
      recAttrAttr2=psop->getValue("ATTR2");
      recAttrAttr3=psop->getValue("ATTR3");

      break;
    }
    case api_record :
    {
      NdbScanOperation::ScanOptions so;

      so.optionsPresent = NdbScanOperation::ScanOptions::SO_INTERPRETED;
      so.interpretedCode= code;

      psop=myTransaction->scanTable(pallColsRecord,
                                    NdbOperation::LM_Read,
                                    NULL, // mask
                                    &so,
                                    sizeof(NdbScanOperation::ScanOptions));

      if (psop == NULL) APIERROR(myTransaction->getNdbError());

      break;
    }
  default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
  }

  if(myTransaction->execute( NdbTransaction::NoCommit ) != 0)
    APIERROR(myTransaction->getNdbError());

  switch (accessType)
  {
    case api_attr :
    {
      while (psop->nextResult(true) == 0)
      {
        printf(" %2d    %2d    %2d\n",
               recAttrAttr1->u_32_value(),
               recAttrAttr2->u_32_value(),
               recAttrAttr3->u_32_value());
      }

      psop->close();

      break;
    }
    case api_record :
    {
      RowData *prowData; // Ptr to point to our data

      int rc=0;
```

```
      while ((rc = psop->nextResult((const char**) &prowData,
                                    true,
                                    false)) == GOT_ROW)
      {
        printf(" %2d    %2d    %2d\n",
               prowData->attr1,
               prowData->attr2,
               prowData->attr3);
      }

      if (rc != NO_MORE_ROWS)  APIERROR(myTransaction->getNdbError());

      psop->close(true);

      break;
    }
    default :
    {
      std::cout << "Bad branch : " << accessType << "\n";
      exit(-1);
    }
  }

  if(myTransaction->execute( NdbTransaction::Commit ) !=0)
    APIERROR(myTransaction->getNdbError());

  myNdb.closeTransaction(myTransaction);

  std::cout << "-------\n";
}

/*******************************************************
 * Read some data using the default NdbRecord objects *
 *******************************************************/
static void do_read_using_default(Ndb &myNdb)
{
  NdbDictionary::Dictionary* myDict= myNdb.getDictionary();

  const NdbDictionary::Table *myTable=
                            myDict->getTable("api_recattr_vs_record");

  const NdbRecord* tableRec= myTable->getDefaultRecord();

  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  std::cout << "Running do_read_using_default_record (NdbRecord only)\n";
  std::cout << "ATTR1 ATTR2 ATTR3" << std::endl;

  /* Allocate some space for the rows to be read into */
  char* buffer= (char*)malloc(NdbDictionary::getRecordRowLength(tableRec));

  if (buffer== NULL)
  {
    printf("Allocation failed\n");
    exit(-1);
  }

  for (int i = 0; i < 10; i++) {
    NdbTransaction *myTransaction= myNdb.startTransaction();
    if (myTransaction == NULL) APIERROR(myNdb.getNdbError());

    char* attr1= NdbDictionary::getValuePtr(tableRec,
                                            buffer,
                                            attr1ColNum);
    *((unsigned int*)attr1)= i;

    const NdbOperation *pop=
      myTransaction->readTuple(tableRec,
                               buffer,
                               tableRec, // Read everything
                               buffer);
```

```
    if (pop==NULL) APIERROR(myTransaction->getNdbError());

    if(myTransaction->execute( NdbTransaction::Commit ) == -1)
      APIERROR(myTransaction->getNdbError());

    NdbError err= myTransaction->getNdbError();
    if (err.code != 0)
    {
      if (err.classification == NdbError::NoDataFound)
        std::cout << "Tuple " << i
                  << " does not exist." << std::endl;
      else
        APIERROR(myTransaction->getNdbError());
    }
    else
    {
      printf(" %2d    %2d    %2d\n",
             i,
             *((unsigned int*) NdbDictionary::getValuePtr(tableRec,
                                                          buffer,
                                                          attr2ColNum)),
             *((unsigned int*) NdbDictionary::getValuePtr(tableRec,
                                                          buffer,
                                                          attr3ColNum)));
    }

    myNdb.closeTransaction(myTransaction);
  }

  free(buffer);

  std::cout << "-------\n";
}
```

2.5.8 NDB API Event Handling Example

This example demonstrates NDB API event handling.

The source code for this program may be found in the NDB Cluster source tree, in the file `storage/ndb/ndbapi-examples/ndbapi_event/ndbapi_event.cpp`.

```
#include <NdbApi.hpp>

// Used for cout
#include <stdio.h>
#include <iostream>
#include <unistd.h>
#ifdef VM_TRACE
#include <my_global.h>
#endif
#ifndef assert
#include <assert.h>
#endif


/**
 * Assume that there is a table which is being updated by
 * another process (e.g. flexBench -l 0 -stdtables).
 * We want to monitor what happens with column values.
 *
 * Or using the mysql client:
 *
 * shell> mysql -u root
 * mysql> create database ndb_examples;
 * mysql> use ndb_examples;
 * mysql> create table t0
          (c0 int, c1 int, c2 char(4), c3 char(4), c4 text,
          primary key(c0, c2)) engine ndb charset latin1;
 *
 * In another window start ndbapi_event, wait until properly started
```

```
   insert into t0 values (1, 2, 'a', 'b', null);
   insert into t0 values (3, 4, 'c', 'd', null);
   update t0 set c3 = 'e' where c0 = 1 and c2 = 'a'; -- use pk
   update t0 set c3 = 'f'; -- use scan
   update t0 set c3 = 'F'; -- use scan update to 'same'
   update t0 set c2 = 'g' where c0 = 1; -- update pk part
   update t0 set c2 = 'G' where c0 = 1; -- update pk part to 'same'
   update t0 set c0 = 5, c2 = 'H' where c0 = 3; -- update full PK
   delete from t0;

   insert ...; update ...; -- see events w/ same pk merged (if -m option)
   delete ...; insert ...; -- there are 5 combinations ID IU DI UD UU
   update ...; update ...;

   -- text requires -m flag
   set @a = repeat('a',256); -- inline size
   set @b = repeat('b',2000); -- part size
   set @c = repeat('c',2000*30); -- 30 parts

   -- update the text field using combinations of @a, @b, @c ...

 * you should see the data popping up in the example window
 *
 */

#define APIERROR(error) \
  { std::cout << "Error in " << __FILE__ << ", line:" << __LINE__ << ", code:" \
              << error.code << ", msg: " << error.message << "." << std::endl; \
    exit(-1); }

int myCreateEvent(Ndb* myNdb,
    const char *eventName,
    const char *eventTableName,
    const char **eventColumnName,
    const int noEventColumnName,
                  bool merge_events);

int main(int argc, char** argv)
{
  if (argc < 3)
  {
    std::cout << "Arguments are <connect_string cluster> <timeout> [m(merge events)|d(debug)].\n";
    exit(-1);
  }
  const char *connection_string = argv[1];
  int timeout = atoi(argv[2]);
  ndb_init();
  bool merge_events = argc > 3 && strchr(argv[3], 'm') != 0;
#ifdef VM_TRACE
  bool dbug = argc > 3 && strchr(argv[3], 'd') != 0;
  if (dbug) DBUG_PUSH("d:t:");
  if (dbug) putenv("API_SIGNAL_LOG=-");
#endif

  Ndb_cluster_connection *cluster_connection=
    new Ndb_cluster_connection(connection_string); // Object representing the cluster

  int r= cluster_connection->connect(5 /* retries               */,
         3 /* delay between retries */,
         1 /* verbose               */);
  if (r > 0)
  {
    std::cout
      << "Cluster connect failed, possibly resolved with more retries.\n";
    exit(-1);
  }
  else if (r < 0)
  {
    std::cout
      << "Cluster connect failed.\n";
    exit(-1);
  }
```

```
if (cluster_connection->wait_until_ready(30,30))
{
  std::cout << "Cluster was not ready within 30 secs." << std::endl;
  exit(-1);
}

Ndb* myNdb= new Ndb(cluster_connection,
      "ndb_examples");  // Object representing the database

if (myNdb->init() == -1) APIERROR(myNdb->getNdbError());

const char *eventName= "CHNG_IN_t0";
const char *eventTableName= "t0";
const int noEventColumnName= 5;
const char *eventColumnName[noEventColumnName]=
  {"c0",
   "c1",
   "c2",
   "c3",
   "c4"
  };

// Create events
myCreateEvent(myNdb,
eventName,
eventTableName,
eventColumnName,
noEventColumnName,
              merge_events);

// Normal values and blobs are unfortunately handled differently..
typedef union { NdbRecAttr* ra; NdbBlob* bh; } RA_BH;

int i, j, k, l;
j = 0;
while (j < timeout) {

  // Start "transaction" for handling events
  NdbEventOperation* op;
  printf("create EventOperation\n");
  if ((op = myNdb->createEventOperation(eventName)) == NULL)
    APIERROR(myNdb->getNdbError());
  op->mergeEvents(merge_events);

  printf("get values\n");
  RA_BH recAttr[noEventColumnName];
  RA_BH recAttrPre[noEventColumnName];
  // primary keys should always be a part of the result
  for (i = 0; i < noEventColumnName; i++) {
    if (i < 4) {
      recAttr[i].ra    = op->getValue(eventColumnName[i]);
      recAttrPre[i].ra = op->getPreValue(eventColumnName[i]);
    } else if (merge_events) {
      recAttr[i].bh    = op->getBlobHandle(eventColumnName[i]);
      recAttrPre[i].bh = op->getPreBlobHandle(eventColumnName[i]);
    }
  }

  // set up the callbacks
  printf("execute\n");
  // This starts changes to "start flowing"
  if (op->execute())
    APIERROR(op->getNdbError());

  NdbEventOperation* the_op = op;

  i= 0;
  while (i < timeout) {
    // printf("now waiting for event...\n");
    int r = myNdb->pollEvents(1000); // wait for event or 1000 ms
    if (r > 0) {
```

```
// printf("got data! %d\n", r);
while ((op= myNdb->nextEvent())) {
         assert(the_op == op);
  i++;
  switch (op->getEventType()) {
  case NdbDictionary::Event::TE_INSERT:
    printf("%u INSERT", i);
    break;
  case NdbDictionary::Event::TE_DELETE:
    printf("%u DELETE", i);
    break;
  case NdbDictionary::Event::TE_UPDATE:
    printf("%u UPDATE", i);
    break;
  default:
    abort(); // should not happen
  }
         printf(" gci=%d\n", (int)op->getGCI());
         for (k = 0; k <= 1; k++) {
           printf(k == 0 ? "post: " : "pre : ");
           for (l = 0; l < noEventColumnName; l++) {
             if (l < 4) {
               NdbRecAttr* ra = k == 0 ? recAttr[l].ra : recAttrPre[l].ra;
               if (ra->isNULL() >= 0) { // we have a value
                 if (ra->isNULL() == 0) { // we have a non-null value
                   if (l < 2)
                     printf("%-5u", ra->u_32_value());
                   else
                     printf("%-5.4s", ra->aRef());
                 } else
                   printf("%-5s", "NULL");
               } else
                 printf("%-5s", "-"); // no value
             } else if (merge_events) {
               int isNull;
               NdbBlob* bh = k == 0 ? recAttr[l].bh : recAttrPre[l].bh;
               bh->getDefined(isNull);
               if (isNull >= 0) { // we have a value
                 if (! isNull) { // we have a non-null value
                   Uint64 length = 0;
                   bh->getLength(length);
                   // read into buffer
                   unsigned char* buf = new unsigned char [length];
                   memset(buf, 'X', length);
                   Uint32 n = length;
                   bh->readData(buf, n); // n is in/out
                   assert(n == length);
                   // pretty-print
                   bool first = true;
                   Uint32 i = 0;
                   while (i < n) {
                     unsigned char c = buf[i++];
                     Uint32 m = 1;
                     while (i < n && buf[i] == c)
                       i++, m++;
                     if (! first)
                       printf("+");
                     printf("%u%c", m, c);
                     first = false;
                   }
                   printf("[%u]", n);
                   delete [] buf;
                 } else
                   printf("%-5s", "NULL");
               } else
                 printf("%-5s", "-"); // no value
             }
           }
           printf("\n");
         }
}
     } // else printf("timed out (%i)\n", timeout);
```

```
    }
    // don't want to listen to events anymore
    if (myNdb->dropEventOperation(the_op)) APIERROR(myNdb->getNdbError());
    the_op = 0;

    j++;
  }

  {
    NdbDictionary::Dictionary *myDict = myNdb->getDictionary();
    if (!myDict) APIERROR(myNdb->getNdbError());
    // remove event from database
    if (myDict->dropEvent(eventName)) APIERROR(myDict->getNdbError());
  }

  delete myNdb;
  delete cluster_connection;
  ndb_end(0);
  return 0;
}

int myCreateEvent(Ndb* myNdb,
    const char *eventName,
    const char *eventTableName,
    const char **eventColumnNames,
    const int noEventColumnNames,
                  bool merge_events)
{
  NdbDictionary::Dictionary *myDict= myNdb->getDictionary();
  if (!myDict) APIERROR(myNdb->getNdbError());

  const NdbDictionary::Table *table= myDict->getTable(eventTableName);
  if (!table) APIERROR(myDict->getNdbError());

  NdbDictionary::Event myEvent(eventName, *table);
  myEvent.addTableEvent(NdbDictionary::Event::TE_ALL);
  //  myEvent.addTableEvent(NdbDictionary::Event::TE_INSERT);
  //  myEvent.addTableEvent(NdbDictionary::Event::TE_UPDATE);
  //  myEvent.addTableEvent(NdbDictionary::Event::TE_DELETE);

  myEvent.addEventColumns(noEventColumnNames, eventColumnNames);
  myEvent.mergeEvents(merge_events);

  // Add event to database
  if (myDict->createEvent(myEvent) == 0)
    myEvent.print();
  else if (myDict->getNdbError().classification ==
    NdbError::SchemaObjectExists) {
    printf("Event creation failed, event exists\n");
    printf("dropping Event...\n");
    if (myDict->dropEvent(eventName)) APIERROR(myDict->getNdbError());
    // try again
    // Add event to database
    if ( myDict->createEvent(myEvent)) APIERROR(myDict->getNdbError());
  } else
    APIERROR(myDict->getNdbError());

  return 0;
}
```

2.5.9 NDB API Example: Basic BLOB Handling

This example illustrates the manipulation of a `BLOB` column in the `NDB` API. It demonstrates how to perform insert, read, and update operations, using both inline value buffers as well as read and write methods.

The source code can be found can be found in the file `storage/ndb/ndbapi-examples/ndbapi_blob/ndbapi_blob.cpp` in the NDB Cluster source tree.

Note

While the MySQL data type used in the example is actually TEXT, the same principles apply

```
/*
  ndbapi_blob.cpp:

  Illustrates the manipulation of BLOB (actually TEXT in this example).

  Shows insert, read, and update, using both inline value buffer and
  read/write methods.
 */

#ifdef _WIN32
#include <winsock2.h>
#endif
#include <mysql.h>
#include <mysqld_error.h>
#include <NdbApi.hpp>
#include <stdlib.h>
#include <string.h>
/* Used for cout. */
#include <iostream>
#include <stdio.h>
#include <ctype.h>


/**
 * Helper debugging macros
 */
#define PRINT_ERROR(code,msg) \
  std::cout << "Error in " << __FILE__ << ", line: " << __LINE__ \
            << ", code: " << code \
            << ", msg: " << msg << "." << std::endl
#define MYSQLERROR(mysql) { \
  PRINT_ERROR(mysql_errno(&mysql),mysql_error(&mysql)); \
  exit(-1); }
#define APIERROR(error) { \
  PRINT_ERROR(error.code,error.message); \
  exit(-1); }

/* Quote taken from Project Gutenberg. */
const char *text_quote=
"Just at this moment, somehow or other, they began to run.\n"
"\n"
"  Alice never could quite make out, in thinking it over\n"
"afterwards, how it was that they began:  all she remembers is,\n"
"that they were running hand in hand, and the Queen went so fast\n"
"that it was all she could do to keep up with her:  and still the\n"
"Queen kept crying 'Faster! Faster!' but Alice felt she COULD NOT\n"
"go faster, though she had not breath left to say so.\n"
"\n"
"  The most curious part of the thing was, that the trees and the\n"
"other things round them never changed their places at all:\n"
"however fast they went, they never seemed to pass anything.  'I\n"
"wonder if all the things move along with us?' thought poor\n"
"puzzled Alice.  And the Queen seemed to guess her thoughts, for\n"
"she cried, 'Faster!  Don't try to talk!'\n"
"\n"
"  Not that Alice had any idea of doing THAT.  She felt as if she\n"
"would never be able to talk again, she was getting so much out of\n"
"breath:  and still the Queen cried 'Faster! Faster!' and dragged\n"
"her along.  'Are we nearly there?'  Alice managed to pant out at\n"
"last.\n"
"\n"
"  'Nearly there!' the Queen repeated.  'Why, we passed it ten\n"
"minutes ago!  Faster!'  And they ran on for a time in silence,\n"
"with the wind whistling in Alice's ears, and almost blowing her\n"
"hair off her head, she fancied.\n"
"\n"
```

```
"  'Now!  Now!' cried the Queen.  'Faster!  Faster!'  And they\n"
"went so fast that at last they seemed to skim through the air,\n"
"hardly touching the ground with their feet, till suddenly, just\n"
"as Alice was getting quite exhausted, they stopped, and she found\n"
"herself sitting on the ground, breathless and giddy.\n"
"\n"
"  The Queen propped her up against a tree, and said kindly, 'You\n"
"may rest a little now.'\n"
"\n"
"  Alice looked round her in great surprise.  'Why, I do believe\n"
"we've been under this tree the whole time!  Everything's just as\n"
"it was!'\n"
"\n"
"  'Of course it is,' said the Queen, 'what would you have it?'\n"
"\n"
"  'Well, in OUR country,' said Alice, still panting a little,\n"
"'you'd generally get to somewhere else--if you ran very fast\n"
"for a long time, as we've been doing.'\n"
"\n"
"  'A slow sort of country!' said the Queen.  'Now, HERE, you see,\n"
"it takes all the running YOU can do, to keep in the same place.\n"
"If you want to get somewhere else, you must run at least twice as\n"
"fast as that!'\n"
"\n"
"  'I'd rather not try, please!' said Alice.  'I'm quite content\n"
"to stay here--only I AM so hot and thirsty!'\n"
"\n"
" -- Lewis Carroll, 'Through the Looking-Glass'.";

/*
  Function to drop table.
*/
void drop_table(MYSQL &mysql)
{
  if (mysql_query(&mysql, "DROP TABLE api_blob"))
    MYSQLERROR(mysql);
}


/*
  Functions to create table.
*/
int try_create_table(MYSQL &mysql)
{
  return mysql_query(&mysql,
                     "CREATE TABLE"
                     "  api_blob"
                     "    (my_id INT UNSIGNED NOT NULL,"
                     "     my_text TEXT NOT NULL,"
                     "     PRIMARY KEY USING HASH (my_id))"
                     "  ENGINE=NDB");
}

void create_table(MYSQL &mysql)
{
  if (try_create_table(mysql))
  {
    if (mysql_errno(&mysql) != ER_TABLE_EXISTS_ERROR)
      MYSQLERROR(mysql);
    std::cout << "NDB Cluster already has example table: api_blob. "
              << "Dropping it..." << std::endl;
    /******************
     * Recreate table *
     ******************/
    drop_table(mysql);
    if (try_create_table(mysql))
      MYSQLERROR(mysql);
  }
}

int populate(Ndb *myNdb)
{
```

```
  const NdbDictionary::Dictionary *myDict= myNdb->getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable("api_blob");
  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  NdbTransaction *myTrans= myNdb->startTransaction();
  if (myTrans == NULL)
    APIERROR(myNdb->getNdbError());

  NdbOperation *myNdbOperation= myTrans->getNdbOperation(myTable);
  if (myNdbOperation == NULL)
    APIERROR(myTrans->getNdbError());
  myNdbOperation->insertTuple();
  myNdbOperation->equal("my_id", 1);
  NdbBlob *myBlobHandle= myNdbOperation->getBlobHandle("my_text");
  if (myBlobHandle == NULL)
    APIERROR(myNdbOperation->getNdbError());
  myBlobHandle->setValue(text_quote, strlen(text_quote));

  int check= myTrans->execute(NdbTransaction::Commit);
  myTrans->close();
  return check != -1;
}


int update_key(Ndb *myNdb)
{
  /*
    Uppercase all characters in TEXT field, using primary key operation.
    Use piece-wise read/write to avoid loading entire data into memory
    at once.
  */
  const NdbDictionary::Dictionary *myDict= myNdb->getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable("api_blob");
  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  NdbTransaction *myTrans= myNdb->startTransaction();
  if (myTrans == NULL)
    APIERROR(myNdb->getNdbError());

  NdbOperation *myNdbOperation= myTrans->getNdbOperation(myTable);
  if (myNdbOperation == NULL)
    APIERROR(myTrans->getNdbError());
  myNdbOperation->updateTuple();
  myNdbOperation->equal("my_id", 1);
  NdbBlob *myBlobHandle= myNdbOperation->getBlobHandle("my_text");
  if (myBlobHandle == NULL)
    APIERROR(myNdbOperation->getNdbError());

  /* Execute NoCommit to make the blob handle active. */
  if (-1 == myTrans->execute(NdbTransaction::NoCommit))
    APIERROR(myTrans->getNdbError());

  Uint64 length= 0;
  if (-1 == myBlobHandle->getLength(length))
    APIERROR(myBlobHandle->getNdbError());

  /*
    A real application should use a much larger chunk size for
    efficiency, preferably much larger than the part size, which
    defaults to 2000. 64000 might be a good value.
  */
#define CHUNK_SIZE 100
  int chunk;
  char buffer[CHUNK_SIZE];
  for (chunk= (length-1)/CHUNK_SIZE; chunk >=0; chunk--)
  {
    Uint64 pos= chunk*CHUNK_SIZE;
    Uint32 chunk_length= CHUNK_SIZE;
    if (pos + chunk_length > length)
      chunk_length= length - pos;
```

```
    /* Read from the end back, to illustrate seeking. */
    if (-1 == myBlobHandle->setPos(pos))
      APIERROR(myBlobHandle->getNdbError());
    if (-1 == myBlobHandle->readData(buffer, chunk_length))
      APIERROR(myBlobHandle->getNdbError());
    int res= myTrans->execute(NdbTransaction::NoCommit);
    if (-1 == res)
      APIERROR(myTrans->getNdbError());

    /* Uppercase everything. */
    for (Uint64 j= 0; j < chunk_length; j++)
      buffer[j]= toupper(buffer[j]);

    if (-1 == myBlobHandle->setPos(pos))
      APIERROR(myBlobHandle->getNdbError());
    if (-1 == myBlobHandle->writeData(buffer, chunk_length))
      APIERROR(myBlobHandle->getNdbError());
    /* Commit on the final update. */
    if (-1 == myTrans->execute(chunk ?
                               NdbTransaction::NoCommit :
                               NdbTransaction::Commit))
      APIERROR(myTrans->getNdbError());
  }

  myNdb->closeTransaction(myTrans);

  return 1;
}


int update_scan(Ndb *myNdb)
{
  /*
    Lowercase all characters in TEXT field, using a scan with
    updateCurrentTuple().
  */
  char buffer[10000];

  const NdbDictionary::Dictionary *myDict= myNdb->getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable("api_blob");
  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  NdbTransaction *myTrans= myNdb->startTransaction();
  if (myTrans == NULL)
    APIERROR(myNdb->getNdbError());

  NdbScanOperation *myScanOp= myTrans->getNdbScanOperation(myTable);
  if (myScanOp == NULL)
    APIERROR(myTrans->getNdbError());
  myScanOp->readTuples(NdbOperation::LM_Exclusive);
  NdbBlob *myBlobHandle= myScanOp->getBlobHandle("my_text");
  if (myBlobHandle == NULL)
    APIERROR(myScanOp->getNdbError());
  if (myBlobHandle->getValue(buffer, sizeof(buffer)))
    APIERROR(myBlobHandle->getNdbError());

  /* Start the scan. */
  if (-1 == myTrans->execute(NdbTransaction::NoCommit))
    APIERROR(myTrans->getNdbError());

  int res;
  for (;;)
  {
    res= myScanOp->nextResult(true);
    if (res==1)
      break;                                    // Scan done.
    else if (res)
      APIERROR(myScanOp->getNdbError());

    Uint64 length= 0;
```

```
    if (myBlobHandle->getLength(length) == -1)
      APIERROR(myBlobHandle->getNdbError());

    /* Lowercase everything. */
    for (Uint64 j= 0; j < length; j++)
      buffer[j]= tolower(buffer[j]);

    NdbOperation *myUpdateOp= myScanOp->updateCurrentTuple();
    if (myUpdateOp == NULL)
      APIERROR(myTrans->getNdbError());
    NdbBlob *myBlobHandle2= myUpdateOp->getBlobHandle("my_text");
    if (myBlobHandle2 == NULL)
      APIERROR(myUpdateOp->getNdbError());
    if (myBlobHandle2->setValue(buffer, length))
      APIERROR(myBlobHandle2->getNdbError());

    if (-1 == myTrans->execute(NdbTransaction::NoCommit))
      APIERROR(myTrans->getNdbError());
  }

  if (-1 == myTrans->execute(NdbTransaction::Commit))
    APIERROR(myTrans->getNdbError());

  myNdb->closeTransaction(myTrans);

  return 1;
}


struct ActiveHookData {
  char buffer[10000];
  Uint32 readLength;
};

int myFetchHook(NdbBlob* myBlobHandle, void* arg)
{
  ActiveHookData *ahd= (ActiveHookData *)arg;

  ahd->readLength= sizeof(ahd->buffer) - 1;
  return myBlobHandle->readData(ahd->buffer, ahd->readLength);
}

int fetch_key(Ndb *myNdb)
{
  /*
    Fetch and show the blob field, using setActiveHook().
  */
  const NdbDictionary::Dictionary *myDict= myNdb->getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable("api_blob");
  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  NdbTransaction *myTrans= myNdb->startTransaction();
  if (myTrans == NULL)
    APIERROR(myNdb->getNdbError());

  NdbOperation *myNdbOperation= myTrans->getNdbOperation(myTable);
  if (myNdbOperation == NULL)
    APIERROR(myTrans->getNdbError());
  myNdbOperation->readTuple();
  myNdbOperation->equal("my_id", 1);
  NdbBlob *myBlobHandle= myNdbOperation->getBlobHandle("my_text");
  if (myBlobHandle == NULL)
    APIERROR(myNdbOperation->getNdbError());
  struct ActiveHookData ahd;
  if (myBlobHandle->setActiveHook(myFetchHook, &ahd) == -1)
    APIERROR(myBlobHandle->getNdbError());

  /*
    Execute Commit, but calling our callback set up in setActiveHook()
    before actually committing.
  */
```

```
  if (-1 == myTrans->execute(NdbTransaction::Commit))
    APIERROR(myTrans->getNdbError());
  myNdb->closeTransaction(myTrans);

  /* Our fetch callback will have been called during the execute(). */

  ahd.buffer[ahd.readLength]= '\0';
  std::cout << "Fetched data:" << std::endl << ahd.buffer << std::endl;

  return 1;
}


int update2_key(Ndb *myNdb)
{
  char buffer[10000];

  /* Simple setValue() update. */
  const NdbDictionary::Dictionary *myDict= myNdb->getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable("api_blob");
  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  NdbTransaction *myTrans= myNdb->startTransaction();
  if (myTrans == NULL)
    APIERROR(myNdb->getNdbError());

  NdbOperation *myNdbOperation= myTrans->getNdbOperation(myTable);
  if (myNdbOperation == NULL)
    APIERROR(myTrans->getNdbError());
  myNdbOperation->updateTuple();
  myNdbOperation->equal("my_id", 1);
  NdbBlob *myBlobHandle= myNdbOperation->getBlobHandle("my_text");
  if (myBlobHandle == NULL)
    APIERROR(myNdbOperation->getNdbError());
  memset(buffer, ' ', sizeof(buffer));
  if (myBlobHandle->setValue(buffer, sizeof(buffer)) == -1)
    APIERROR(myBlobHandle->getNdbError());

  if (-1 == myTrans->execute(NdbTransaction::Commit))
    APIERROR(myTrans->getNdbError());
  myNdb->closeTransaction(myTrans);

  return 1;
}


int delete_key(Ndb *myNdb)
{
  /* Deletion of blob row. */
  const NdbDictionary::Dictionary *myDict= myNdb->getDictionary();
  const NdbDictionary::Table *myTable= myDict->getTable("api_blob");
  if (myTable == NULL)
    APIERROR(myDict->getNdbError());

  NdbTransaction *myTrans= myNdb->startTransaction();
  if (myTrans == NULL)
    APIERROR(myNdb->getNdbError());

  NdbOperation *myNdbOperation= myTrans->getNdbOperation(myTable);
  if (myNdbOperation == NULL)
    APIERROR(myTrans->getNdbError());
  myNdbOperation->deleteTuple();
  myNdbOperation->equal("my_id", 1);

  if (-1 == myTrans->execute(NdbTransaction::Commit))
    APIERROR(myTrans->getNdbError());
  myNdb->closeTransaction(myTrans);

  return 1;
}
```

```
void mysql_connect_and_create(const char *socket)
{
  MYSQL mysql;
  bool ok;

  mysql_init(&mysql);

  ok = mysql_real_connect(&mysql, "localhost", "root", "", "", 0, socket, 0);
  if(ok) {
    mysql_query(&mysql, "CREATE DATABASE ndb_examples");
    ok = ! mysql_select_db(&mysql, "ndb_examples");
  }
  if(ok) {
    create_table(mysql);
  }
  mysql_close(&mysql);

  if(! ok) MYSQLERROR(mysql);
}

void ndb_run_blob_operations(const char *connectstring)
{
  /* Connect to ndb cluster. */
  Ndb_cluster_connection cluster_connection(connectstring);
  if (cluster_connection.connect(4, 5, 1))
  {
    std::cout << "Unable to connect to cluster within 30 secs." << std::endl;
    exit(-1);
  }
  /* Optionally connect and wait for the storage nodes (ndbd's). */
  if (cluster_connection.wait_until_ready(30,0) < 0)
  {
    std::cout << "Cluster was not ready within 30 secs.\n";
    exit(-1);
  }

  Ndb myNdb(&cluster_connection,"ndb_examples");
  if (myNdb.init(1024) == -1) {      // Set max 1024 parallel transactions
    APIERROR(myNdb.getNdbError());
    exit(-1);
  }

  if(populate(&myNdb) > 0)
    std::cout << "populate: Success!" << std::endl;

  if(update_key(&myNdb) > 0)
    std::cout << "update_key: Success!" << std::endl;

  if(update_scan(&myNdb) > 0)
    std::cout << "update_scan: Success!" << std::endl;

  if(fetch_key(&myNdb) > 0)
    std::cout << "fetch_key: Success!" << std::endl;

  if(update2_key(&myNdb) > 0)
    std::cout << "update2_key: Success!" << std::endl;

  if(delete_key(&myNdb) > 0)
    std::cout << "delete_key: Success!" << std::endl;
}

int main(int argc, char**argv)
{
  if (argc != 3)
  {
    std::cout << "Arguments are <socket mysqld> <connect_string cluster>.\n";
    exit(-1);
  }
  char *mysqld_sock  = argv[1];
  const char *connectstring = argv[2];

  mysql_connect_and_create(mysqld_sock);
```

```
  ndb_init();
  ndb_run_blob_operations(connectstring);
  ndb_end(0);

  return 0;
}
```

2.5.10 NDB API Example: Handling BLOB Columns and Values Using NdbRecord

This example illustrates the manipulation of a `BLOB` column in the NDB API using the `NdbRecord` interface. It demonstrates how to perform insert, read, and update operations, using both inline value buffers as well as read and write methods. It can be found in the file `storage/ndb/ndbapi-examples/ndbapi_blob_ndbrecord/main.cpp` in the NDB Cluster source trees.

Note

While the MySQL data type used in the example is actually `TEXT`, the same principles apply

```
/*
  ndbapi_blob_ndbrecord

  Illustrates the manipulation of BLOB (actually TEXT in this example).
  This example uses the NdbRecord style way of accessing tuples.

  Shows insert, read, and update, using both inline value buffer and
  read/write methods.
 */

#ifdef _WIN32
#include <winsock2.h>
#endif
#include <mysql.h>
#include <mysqld_error.h>
#include <NdbApi.hpp>
/* Used for cout. */
#include <iostream>
#include <stdio.h>
#include <ctype.h>
#include <stdlib.h>
#include <stddef.h>
#include <string.h>

/**
 * Helper debugging macros
 */
#define PRINT_ERROR(code,msg) \
  std::cout << "Error in " << __FILE__ << ", line: " << __LINE__ \
            << ", code: " << code \
            << ", msg: " << msg << "." << std::endl
#define MYSQLERROR(mysql) { \
  PRINT_ERROR(mysql_errno(&mysql),mysql_error(&mysql)); \
  exit(-1); }
#define APIERROR(error) { \
  PRINT_ERROR(error.code,error.message); \
  exit(-1); }

/* Quote taken from Project Gutenberg. */
const char *text_quote=
"Just at this moment, somehow or other, they began to run.\n"
"\n"
"  Alice never could quite make out, in thinking it over\n"
"afterwards, how it was that they began:  all she remembers is,\n"
"that they were running hand in hand, and the Queen went so fast\n"
"that it was all she could do to keep up with her:  and still the\n"
"Queen kept crying 'Faster! Faster!' but Alice felt she COULD NOT\n"
"go faster, though she had not breath left to say so.\n"
```

```
"\n"
"  The most curious part of the thing was, that the trees and the\n"
"other things round them never changed their places at all:\n"
"however fast they went, they never seemed to pass anything.  'I\n"
"wonder if all the things move along with us?' thought poor\n"
"puzzled Alice.  And the Queen seemed to guess her thoughts, for\n"
"she cried, 'Faster!  Don't try to talk!'\n"
"\n"
"  Not that Alice had any idea of doing THAT.  She felt as if she\n"
"would never be able to talk again, she was getting so much out of\n"
"breath:  and still the Queen cried 'Faster! Faster!' and dragged\n"
"her along.  'Are we nearly there?'  Alice managed to pant out at\n"
"last.\n"
"\n"
"  'Nearly there!' the Queen repeated.  'Why, we passed it ten\n"
"minutes ago!  Faster!'  And they ran on for a time in silence,\n"
"with the wind whistling in Alice's ears, and almost blowing her\n"
"hair off her head, she fancied.\n"
"\n"
"  'Now!  Now!' cried the Queen.  'Faster!  Faster!'  And they\n"
"went so fast that at last they seemed to skim through the air,\n"
"hardly touching the ground with their feet, till suddenly, just\n"
"as Alice was getting quite exhausted, they stopped, and she found\n"
"herself sitting on the ground, breathless and giddy.\n"
"\n"
"  The Queen propped her up against a tree, and said kindly, 'You\n"
"may rest a little now.'\n"
"\n"
"  Alice looked round her in great surprise.  'Why, I do believe\n"
"we've been under this tree the whole time!  Everything's just as\n"
"it was!'\n"
"\n"
"  'Of course it is,' said the Queen, 'what would you have it?'\n"
"\n"
"  'Well, in OUR country,' said Alice, still panting a little,\n"
"'you'd generally get to somewhere else--if you ran very fast\n"
"for a long time, as we've been doing.'\n"
"\n"
"  'A slow sort of country!' said the Queen.  'Now, HERE, you see,\n"
"it takes all the running YOU can do, to keep in the same place.\n"
"If you want to get somewhere else, you must run at least twice as\n"
"fast as that!'\n"
"\n"
"  'I'd rather not try, please!' said Alice.  'I'm quite content\n"
"to stay here--only I AM so hot and thirsty!'\n"
"\n"
" -- Lewis Carroll, 'Through the Looking-Glass'.";

/* NdbRecord objects. */

const NdbRecord *key_record;                    // For specifying table key
const NdbRecord *blob_record;                   // For accessing blob
const NdbRecord *full_record;                   // All columns, for insert

/* C struct representing the row layout */
struct MyRow
{
  unsigned int myId;

  /* Pointer to Blob handle for operations on the blob column
   * Space must be left for it in the row, but a pointer to the
   * blob handle can also be obtained via calls to
   * NdbOperation::getBlobHandle()
   */
  NdbBlob* myText;
};

static void setup_records(Ndb *myNdb)
{
  NdbDictionary::RecordSpecification spec[2];

  NdbDictionary::Dictionary *myDict= myNdb->getDictionary();
```

```
  const NdbDictionary::Table *myTable= myDict->getTable("api_blob_ndbrecord");
  if (myTable == NULL)
    APIERROR(myDict->getNdbError());
  const NdbDictionary::Column *col1= myTable->getColumn("my_id");
  if (col1 == NULL)
    APIERROR(myDict->getNdbError());
  const NdbDictionary::Column *col2= myTable->getColumn("my_text");
  if (col2 == NULL)
    APIERROR(myDict->getNdbError());

  spec[0].column= col1;
  spec[0].offset= offsetof(MyRow, myId);
  spec[0].nullbit_byte_offset= 0;
  spec[0].nullbit_bit_in_byte= 0;
  spec[1].column= col2;
  spec[1].offset= offsetof(MyRow, myText);
  spec[1].nullbit_byte_offset= 0;
  spec[1].nullbit_bit_in_byte= 0;

  key_record= myDict->createRecord(myTable, &spec[0], 1, sizeof(spec[0]));
  if (key_record == NULL)
    APIERROR(myDict->getNdbError());
  blob_record= myDict->createRecord(myTable, &spec[1], 1, sizeof(spec[0]));
  if (blob_record == NULL)
    APIERROR(myDict->getNdbError());
  full_record= myDict->createRecord(myTable, &spec[0], 2, sizeof(spec[0]));
  if (full_record == NULL)
    APIERROR(myDict->getNdbError());
}

/*
  Function to drop table.
*/
void drop_table(MYSQL &mysql)
{
  if (mysql_query(&mysql, "DROP TABLE api_blob_ndbrecord"))
    MYSQLERROR(mysql);
}


/*
  Functions to create table.
*/
int try_create_table(MYSQL &mysql)
{
  return mysql_query(&mysql,
                     "CREATE TABLE"
                     "  api_blob_ndbrecord"
                     "    (my_id INT UNSIGNED NOT NULL,"
                     "     my_text TEXT NOT NULL,"
                     "     PRIMARY KEY USING HASH (my_id))"
                     "  ENGINE=NDB");
}

void create_table(MYSQL &mysql)
{
  if (try_create_table(mysql))
  {
    if (mysql_errno(&mysql) != ER_TABLE_EXISTS_ERROR)
      MYSQLERROR(mysql);
    std::cout << "NDB Cluster already has example table: api_blob_ndbrecord. "
              << "Dropping it..." << std::endl;
    /******************
     * Recreate table *
     ******************/
    drop_table(mysql);
    if (try_create_table(mysql))
      MYSQLERROR(mysql);
  }
}

int populate(Ndb *myNdb)
```

```
{
  MyRow row;

  NdbTransaction *myTrans= myNdb->startTransaction();
  if (myTrans == NULL)
    APIERROR(myNdb->getNdbError());

  row.myId= 1;
  const NdbOperation *myNdbOperation= myTrans->insertTuple(full_record, (const char*) &row);
  if (myNdbOperation == NULL)
    APIERROR(myTrans->getNdbError());

  NdbBlob *myBlobHandle= myNdbOperation->getBlobHandle("my_text");
  if (myBlobHandle == NULL)
    APIERROR(myNdbOperation->getNdbError());
  myBlobHandle->setValue(text_quote, strlen(text_quote));

  int check= myTrans->execute(NdbTransaction::Commit);
  myTrans->close();
  return check != -1;
}


int update_key(Ndb *myNdb)
{
  MyRow row;

  /*
    Uppercase all characters in TEXT field, using primary key operation.
    Use piece-wise read/write to avoid loading entire data into memory
    at once.
  */

  NdbTransaction *myTrans= myNdb->startTransaction();
  if (myTrans == NULL)
    APIERROR(myNdb->getNdbError());

  row.myId= 1;

  const NdbOperation *myNdbOperation=
    myTrans->updateTuple(key_record,
                         (const char*) &row,
                         blob_record,
                         (const char*) &row);
  if (myNdbOperation == NULL)
    APIERROR(myTrans->getNdbError());

  NdbBlob *myBlobHandle= myNdbOperation->getBlobHandle("my_text");
  if (myBlobHandle == NULL)
    APIERROR(myNdbOperation->getNdbError());

  /* Execute NoCommit to make the blob handle active so
   * that we can determine the actual Blob length
   */
  if (-1 == myTrans->execute(NdbTransaction::NoCommit))
    APIERROR(myTrans->getNdbError());

  Uint64 length= 0;
  if (-1 == myBlobHandle->getLength(length))
    APIERROR(myBlobHandle->getNdbError());

  /*
    A real application should use a much larger chunk size for
    efficiency, preferably much larger than the part size, which
    defaults to 2000. 64000 might be a good value.
  */
#define CHUNK_SIZE 100
  int chunk;
  char buffer[CHUNK_SIZE];
  for (chunk= (length-1)/CHUNK_SIZE; chunk >=0; chunk--)
  {
    Uint64 pos= chunk*CHUNK_SIZE;
```

```
    Uint32 chunk_length= CHUNK_SIZE;
    if (pos + chunk_length > length)
      chunk_length= length - pos;

    /* Read from the end back, to illustrate seeking. */
    if (-1 == myBlobHandle->setPos(pos))
      APIERROR(myBlobHandle->getNdbError());
    if (-1 == myBlobHandle->readData(buffer, chunk_length))
      APIERROR(myBlobHandle->getNdbError());
    int res= myTrans->execute(NdbTransaction::NoCommit);
    if (-1 == res)
      APIERROR(myTrans->getNdbError());

    /* Uppercase everything. */
    for (Uint64 j= 0; j < chunk_length; j++)
      buffer[j]= toupper(buffer[j]);

    if (-1 == myBlobHandle->setPos(pos))
      APIERROR(myBlobHandle->getNdbError());
    if (-1 == myBlobHandle->writeData(buffer, chunk_length))
      APIERROR(myBlobHandle->getNdbError());
    /* Commit on the final update. */
    if (-1 == myTrans->execute(chunk ?
                               NdbTransaction::NoCommit :
                               NdbTransaction::Commit))
      APIERROR(myTrans->getNdbError());
  }

  myNdb->closeTransaction(myTrans);

  return 1;
}


int update_scan(Ndb *myNdb)
{
  /*
    Lowercase all characters in TEXT field, using a scan with
    updateCurrentTuple().
  */
  char buffer[10000];

  NdbTransaction *myTrans= myNdb->startTransaction();
  if (myTrans == NULL)
    APIERROR(myNdb->getNdbError());

  NdbScanOperation *myScanOp=
    myTrans->scanTable(blob_record, NdbOperation::LM_Exclusive);
  if (myScanOp == NULL)
    APIERROR(myTrans->getNdbError());
  NdbBlob *myBlobHandle= myScanOp->getBlobHandle("my_text");
  if (myBlobHandle == NULL)
    APIERROR(myScanOp->getNdbError());
  if (myBlobHandle->getValue(buffer, sizeof(buffer)))
    APIERROR(myBlobHandle->getNdbError());

  /* Start the scan. */
  if (-1 == myTrans->execute(NdbTransaction::NoCommit))
    APIERROR(myTrans->getNdbError());

  const MyRow *out_row;
  int res;
  for (;;)
  {
    res= myScanOp->nextResult((const char**)&out_row, true, false);
    if (res==1)
      break;                                    // Scan done.
    else if (res)
      APIERROR(myScanOp->getNdbError());

    Uint64 length= 0;
    if (myBlobHandle->getLength(length) == -1)
```

```
      APIERROR(myBlobHandle->getNdbError());

    /* Lowercase everything. */
    for (Uint64 j= 0; j < length; j++)
      buffer[j]= tolower(buffer[j]);

    /* 'Take over' the row locks from the scan to a separate
     * operation for updating the tuple
     */
    const NdbOperation *myUpdateOp=
      myScanOp->updateCurrentTuple(myTrans,
                                   blob_record,
                                   (const char*)out_row);
    if (myUpdateOp == NULL)
      APIERROR(myTrans->getNdbError());
    NdbBlob *myBlobHandle2= myUpdateOp->getBlobHandle("my_text");
    if (myBlobHandle2 == NULL)
      APIERROR(myUpdateOp->getNdbError());
    if (myBlobHandle2->setValue(buffer, length))
      APIERROR(myBlobHandle2->getNdbError());

    if (-1 == myTrans->execute(NdbTransaction::NoCommit))
      APIERROR(myTrans->getNdbError());
  }

  if (-1 == myTrans->execute(NdbTransaction::Commit))
    APIERROR(myTrans->getNdbError());

  myNdb->closeTransaction(myTrans);

  return 1;
}


struct ActiveHookData {
  char buffer[10000];
  Uint32 readLength;
};

int myFetchHook(NdbBlob* myBlobHandle, void* arg)
{
  ActiveHookData *ahd= (ActiveHookData *)arg;

  ahd->readLength= sizeof(ahd->buffer) - 1;
  return myBlobHandle->readData(ahd->buffer, ahd->readLength);
}

int fetch_key(Ndb *myNdb)
{
  /* Fetch a blob without specifying how many bytes
   * to read up front, in one execution using
   * the 'ActiveHook' mechanism.
   * The supplied ActiveHook procedure is called when
   * the Blob handle becomes 'active'.  At that point
   * the length of the Blob can be obtained, and buffering
   * arranged, and the data read requested.
   */

  /* Separate rows used to specify key and hold result */
  MyRow key_row;
  MyRow out_row;

  /*
    Fetch and show the blob field, using setActiveHook().
  */

  NdbTransaction *myTrans= myNdb->startTransaction();
  if (myTrans == NULL)
    APIERROR(myNdb->getNdbError());

  key_row.myId= 1;
  out_row.myText= NULL;
```

```
  const NdbOperation *myNdbOperation=
    myTrans->readTuple(key_record,
                       (const char*) &key_row,
                       blob_record,
                       (char*) &out_row);
  if (myNdbOperation == NULL)
    APIERROR(myTrans->getNdbError());

  /* This time, we'll get the blob handle from the row, because
   * we can.  Alternatively, we could use the normal mechanism
   * of calling getBlobHandle().
   */
  NdbBlob *myBlobHandle= out_row.myText;
  if (myBlobHandle == NULL)
    APIERROR(myNdbOperation->getNdbError());
  struct ActiveHookData ahd;
  if (myBlobHandle->setActiveHook(myFetchHook, &ahd) == -1)
    APIERROR(myBlobHandle->getNdbError());

  /*
    Execute Commit, but calling our callback set up in setActiveHook()
    before actually committing.
  */
  if (-1 == myTrans->execute(NdbTransaction::Commit))
    APIERROR(myTrans->getNdbError());
  myNdb->closeTransaction(myTrans);

  /* Our fetch callback will have been called during the execute(). */

  ahd.buffer[ahd.readLength]= '\0';
  std::cout << "Fetched data:" << std::endl << ahd.buffer << std::endl;

  return 1;
}


int update2_key(Ndb *myNdb)
{
  char buffer[10000];
  MyRow row;

  /* Simple setValue() update specified before the
   * Blob handle is made active
   */

  NdbTransaction *myTrans= myNdb->startTransaction();
  if (myTrans == NULL)
    APIERROR(myNdb->getNdbError());

  row.myId= 1;
  const NdbOperation *myNdbOperation=
    myTrans->updateTuple(key_record,
                         (const char*)&row,
                         blob_record,
                         (char*) &row);
  if (myNdbOperation == NULL)
    APIERROR(myTrans->getNdbError());
  NdbBlob *myBlobHandle= myNdbOperation->getBlobHandle("my_text");
  if (myBlobHandle == NULL)
    APIERROR(myNdbOperation->getNdbError());
  memset(buffer, ' ', sizeof(buffer));
  if (myBlobHandle->setValue(buffer, sizeof(buffer)) == -1)
    APIERROR(myBlobHandle->getNdbError());

  if (-1 == myTrans->execute(NdbTransaction::Commit))
    APIERROR(myTrans->getNdbError());
  myNdb->closeTransaction(myTrans);

  return 1;
}
```

```
int delete_key(Ndb *myNdb)
{
  MyRow row;

  /* Deletion of row containing blob via primary key. */

  NdbTransaction *myTrans= myNdb->startTransaction();
  if (myTrans == NULL)
    APIERROR(myNdb->getNdbError());

  row.myId= 1;
  const NdbOperation *myNdbOperation= myTrans->deleteTuple(key_record,
                                                           (const char*)&row,
                                                           full_record);
  if (myNdbOperation == NULL)
    APIERROR(myTrans->getNdbError());

  if (-1 == myTrans->execute(NdbTransaction::Commit))
    APIERROR(myTrans->getNdbError());
  myNdb->closeTransaction(myTrans);

  return 1;
}

void mysql_connect_and_create(const char *socket)
{
  MYSQL mysql;
  bool ok;

  mysql_init(&mysql);

  ok = mysql_real_connect(&mysql, "localhost", "root", "", "", 0, socket, 0);
  if(ok) {
    mysql_query(&mysql, "CREATE DATABASE ndb_examples");
    ok = ! mysql_select_db(&mysql, "ndb_examples");
  }
  if(ok) {
    create_table(mysql);
  }
  mysql_close(&mysql);

  if(! ok) MYSQLERROR(mysql);
}

void ndb_run_ndbrecord_blob_operations(const char * connectstring)
{
  /* Connect to ndb cluster. */

  Ndb_cluster_connection cluster_connection(connectstring);
  if (cluster_connection.connect(4, 5, 1))
  {
    std::cout << "Unable to connect to cluster within 30 secs." << std::endl;
    exit(-1);
  }
  /* Optionally connect and wait for the storage nodes (ndbd's). */
  if (cluster_connection.wait_until_ready(30,0) < 0)
  {
    std::cout << "Cluster was not ready within 30 secs.\n";
    exit(-1);
  }

  Ndb myNdb(&cluster_connection,"ndb_examples");
  if (myNdb.init(1024) == -1) {      // Set max 1024 parallel transactions
    APIERROR(myNdb.getNdbError());
    exit(-1);
  }

  setup_records(&myNdb);

  if(populate(&myNdb) > 0)
    std::cout << "populate: Success!" << std::endl;
```

```
  if(update_key(&myNdb) > 0)
    std::cout << "update_key: Success!" << std::endl;

  if(update_scan(&myNdb) > 0)
    std::cout << "update_scan: Success!" << std::endl;

  if(fetch_key(&myNdb) > 0)
    std::cout << "fetch_key: Success!" << std::endl;

  if(update2_key(&myNdb) > 0)
    std::cout << "update2_key: Success!" << std::endl;

  if(delete_key(&myNdb) > 0)
    std::cout << "delete_key: Success!" << std::endl;
}

int main(int argc, char**argv)
{
  if (argc != 3)
  {
    std::cout << "Arguments are <socket mysqld> <connect_string cluster>.\n";
    exit(-1);
  }
  char *mysqld_sock  = argv[1];
  const char *connectstring = argv[2];

  mysql_connect_and_create(mysqld_sock);

  ndb_init();
  ndb_run_ndbrecord_blob_operations(connectstring);
  ndb_end(0);

  return 0;
}
```

2.5.11 NDB API Simple Array Example

This program inserts `CHAR`, `VARCHAR`, and `BINARY` column data into a table by constructing `aRef` objects using local functions. It then reads the columns back and extracts the data from them using local functions.

This example assumes you have a table named `api_array_simple`, created as follows:

```
CREATE TABLE api_array_simple (
    ATTR1 INT UNSIGNED NOT NULL PRIMARY KEY,
    ATTR2 CHAR(20) NOT NULL,
    ATTR3 VARCHAR(20) NOT NULL,
    ATTR4 VARCHAR(500) NOT NULL,
    ATTR5 BINARY(20) NOT NULL,
    ATTR6 VARBINARY(20) NOT NULL,
    ATTR7 VARBINARY(500) NOT NULL
) ENGINE NDB CHARSET latin1;
```

Note

This program uses a number of utilities which can be found in `storage/ndb/ndbapi-examples/common/`. See Section 2.5.14, “Common Files for NDB API Array Examples”, for listings of these.

The example file can be found as `ndbapi_array_simple/ndbapi_array_simple.cpp` in the NDB 7.3.8, NDB 7.4.3, or later NDB Cluster source distribution's `storage/ndb/ndbapi-examples` directory. (Bug #70550, Bug #17592990)

```
#include <NdbApi.hpp>
#include <iostream>
#include <vector>
#include <cstdlib>
#include <cstring>

/*
```

```
  See Section 2.5.14, “Common Files for NDB API Array Examples”,
  for listings of these utilities.
*/
#include "../common/error_handling.hpp"
#include "../common/ndb_util.hpp"
#include "../common/util.hpp"

using namespace std;

/* structure to help in insertion */
struct RowData
{
  /* id */
  int attr1;
  /* CHAR(20)- fixed length, no additional length bytes */
  char attr2[20];
  /* VARCHAR(20) - requires one additional length byte (length < 256 ) */
  char attr3[1 + 20];
  /* VARCHAR(500) - requires two additional length bytes (length > 256 ) */
  char attr4[2 + 500];
  /* BINARY(20) - fixed length, requires no additional length byte */
  char attr5[20];
  /* VARBINARY(20) - requires one additional length byte (length < 256 ) */
  char attr6[1 + 20];
  /* VARBINARY(20) - requires one additional length byte (length > 256 ) */
  char attr7[2 + 500];
};

/* extracts the length and the start byte of the data stored */
static int get_byte_array(const NdbRecAttr* attr,
                          const char*& first_byte,
                          size_t& bytes)
{
  const NdbDictionary::Column::ArrayType array_type =
    attr->getColumn()->getArrayType();
  const size_t attr_bytes = attr->get_size_in_bytes();
  const char* aRef = attr->aRef();
  string result;

  switch (array_type) {
  case NdbDictionary::Column::ArrayTypeFixed:
    /*
     No prefix length is stored in aRef. Data starts from aRef's first byte
     data might be padded with blank or null bytes to fill the whole column
     */
    first_byte = aRef;
    bytes = attr_bytes;
    return 0;
  case NdbDictionary::Column::ArrayTypeShortVar:
    /*
     First byte of aRef has the length of data stored
     Data starts from second byte of aRef
     */
    first_byte = aRef + 1;
    bytes = (size_t)(aRef[0]);
    return 0;
  case NdbDictionary::Column::ArrayTypeMediumVar:
    /*
     First two bytes of aRef has the length of data stored
     Data starts from third byte of aRef
     */
    first_byte = aRef + 2;
    bytes = (size_t)(aRef[1]) * 256 + (size_t)(aRef[0]);
    return 0;
  default:
    first_byte = NULL;
    bytes = 0;
    return -1;
  }
}

/*
```

```
 Extracts the string from given NdbRecAttr
 Uses get_byte_array internally
 */
static int get_string(const NdbRecAttr* attr, string& str)
{
  size_t attr_bytes;
  const char* data_start_ptr = NULL;

  /* get stored length and data using get_byte_array */
  if(get_byte_array(attr, data_start_ptr, attr_bytes) == 0)
  {
    /* we have length of the string and start location */
    str= string(data_start_ptr, attr_bytes);
    if(attr->getType() == NdbDictionary::Column::Char)
    {
      /* Fixed Char : remove blank spaces at the end */
      size_t endpos = str.find_last_not_of(" ");
      if( string::npos != endpos )
      {
        str = str.substr(0, endpos+1);
      }
    }
  }
  return 0;
}

// Do a cleanup of all inserted tuples
static void do_cleanup(Ndb& ndb)
{
  const NdbDictionary::Dictionary* dict = ndb.getDictionary();

  const NdbDictionary::Table *table = dict->getTable("api_array_simple");
  if (table == nullptr) APIERROR(dict->getNdbError());

  NdbTransaction *transaction= ndb.startTransaction();
  if (transaction == nullptr) APIERROR(ndb.getNdbError());

  for (int i = 0; i <= 20; i++)
  {
    NdbOperation* myOperation = transaction->getNdbOperation(table);
    if (myOperation == nullptr) APIERROR(transaction->getNdbError());
    myOperation->deleteTuple();
    myOperation->equal("ATTR1", i);
  }

  if (transaction->execute(NdbTransaction::Commit) != 0)
  {
    APIERROR(transaction->getNdbError());
  }
  ndb.closeTransaction(transaction);
}

/*******************************************************
 * Use one transaction and insert 21 rows in one batch *
 *******************************************************/
static void do_insert(Ndb& ndb)
{
  const NdbDictionary::Dictionary* dict = ndb.getDictionary();
  const NdbDictionary::Table *table = dict->getTable("api_array_simple");

  if (table == NULL) APIERROR(dict->getNdbError());

  NdbTransaction *transaction= ndb.startTransaction();
  if (transaction == NULL) APIERROR(ndb.getNdbError());

  /* Create and initialize sample data */
  const string meter = 50 * string("''''-,,,,|");
  const string space = 20 * string(" ");
  unsigned char binary_meter[500];
  for (unsigned i = 0; i < 500; i++)
  {
    binary_meter[i] = (unsigned char)(i % 256);
```

```
}

vector<NdbOperation*> operations;
for (int i = 0; i <= 20; i++)
{
  RowData data;
  NdbOperation* myOperation = transaction->getNdbOperation(table);
  if (myOperation == NULL) APIERROR(transaction->getNdbError());
  data.attr1 = i;

  // Fill CHAR(20) with 'i' chars from meter
  strncpy (data.attr2, meter.c_str(), i);
  // Pad it with space up to 20 chars
  strncpy (data.attr2 + i, space.c_str(), 20 - i);

  // Fill VARCHAR(20) with 'i' chars from meter. First byte is
  // reserved for length field. No padding is needed.
  strncpy (data.attr3 + 1, meter.c_str(), i);
  // Set the length byte
  data.attr3[0] = (char)i;

  // Fill VARCHAR(500) with 20*i chars from meter. First two bytes
  // are reserved for length field. No padding is needed.
  strncpy (data.attr4 + 2, meter.c_str(), 20*i);
  // Set the length bytes
  data.attr4[0] = (char)(20*i % 256);
  data.attr4[1] = (char)(20*i / 256);

  // Fill BINARY(20) with 'i' bytes from binary_meter.
  memcpy(data.attr5, binary_meter, i);
  // Pad with 0 up to 20 bytes.
  memset(data.attr5 + i, 0, 20 - i);

  // Fill VARBINARY(20) with 'i' bytes from binary_meter. First byte
  // is reserved for length field. No padding is needed.
  memcpy(data.attr6 + 1, binary_meter, i);
  // Set the length byte
  data.attr6[0] = (char)i;

  // Fill VARBINARY(500) with 'i' bytes from binary_meter. First two
  // bytes are reserved for length filed. No padding is needed.
  memcpy(data.attr7 + 2, binary_meter, 20*i);
  // Set the length bytes
  data.attr7[0] = (char)(20*i % 256);
  data.attr7[1] = (char)(20*i / 256);

  myOperation->insertTuple();
  myOperation->equal("ATTR1", data.attr1);
  myOperation->setValue("ATTR2", data.attr2);
  myOperation->setValue("ATTR3", data.attr3);
  myOperation->setValue("ATTR4", data.attr4);
  myOperation->setValue("ATTR5", data.attr5);
  myOperation->setValue("ATTR6", data.attr6);
  myOperation->setValue("ATTR7", data.attr7);

  operations.push_back(myOperation);
}

// Now execute all operations in one batch, and check for errors.
if (transaction->execute( NdbTransaction::Commit ) != 0)
{
  for (size_t i = 0; i < operations.size(); i++)
  {
    const NdbError err= operations[i]->getNdbError();
    if(err.code != NdbError::Success)
    {
      cout << "Error inserting Row : " << i << endl;
      PRINT_ERROR(err.code, err.message);
    }
  }
  APIERROR(transaction->getNdbError());
}
```

```
  ndb.closeTransaction(transaction);
}

/*
 Reads the row with id = 17
 Retrieves an prints value of the [VAR]CHAR/BINARY
 */
static void do_read(Ndb& ndb)
{
  const NdbDictionary::Dictionary* dict= ndb.getDictionary();
  const NdbDictionary::Table* table= dict->getTable("api_array_simple");

  if (table == NULL) APIERROR(dict->getNdbError());

  NdbTransaction *transaction= ndb.startTransaction();
  if (transaction == NULL) APIERROR(ndb.getNdbError());

  NdbOperation *operation= transaction->getNdbOperation(table);
  if (operation == NULL) APIERROR(transaction->getNdbError());

  /* create and execute a read operation */
  operation->readTuple(NdbOperation::LM_Read);
  operation->equal("ATTR1", 17);

  vector<NdbRecAttr*> attr;
  const int column_count= table->getNoOfColumns();
  attr.reserve(column_count);

  attr.push_back(nullptr);

  for (int i= 1; i < column_count; i++)
  {
    attr.push_back(operation->getValue(i, NULL));
    if (attr[i] == NULL) APIERROR(transaction->getNdbError());
  }

  if(transaction->execute( NdbTransaction::Commit ) == -1)
    APIERROR(transaction->getNdbError());

  /* print the fetched data */
  cout << "Row ID : 17\n";
  for (int i= 1; i < column_count; i++)
  {
    if (attr[i] != NULL)
    {
      NdbDictionary::Column::Type column_type = attr[i]->getType();
      cout << "Column id: " << i << ", name: " << attr[i]->getColumn()->getName()
           << ", size: " << attr[i]->get_size_in_bytes()
           << ", type: " << column_type_to_string(attr[i]->getType());
      switch (column_type) {
      case NdbDictionary::Column::Char:
      case NdbDictionary::Column::Varchar:
      case NdbDictionary::Column::Longvarchar:
        {
          /* for char columns the actual string is printed */
          string str;
          get_string(attr[i], str);
          cout << ", stored string length: " << str.length()
               << ", value: " << str << endl;
        }
        break;
      case NdbDictionary::Column::Binary:
      case NdbDictionary::Column::Varbinary:
      case NdbDictionary::Column::Longvarbinary:
        {
          /* for binary columns the sum of all stored bytes is printed */
          const char* first;
          size_t count;
          get_byte_array(attr[i], first, count);
          int sum = 0;
          for (const char* byte = first; byte < first + count; byte++)
          {
```

```
            sum += (int)(*byte);
          }
          cout << ", stored bytes length: " << count
               << ", sum of byte array: " << sum << endl;
        }
        break;
      default:
        cout << ", column type \"" << column_type_to_string(attr[i]->getType())
             << "\" not covered by this example" << endl;
        break;
      }
    }
  }

  ndb.closeTransaction(transaction);
}

static void run_application(Ndb_cluster_connection &cluster_connection,
                            const char* database_name)
{
  /********************************************
   * Connect to database via NdbApi           *
   ********************************************/
  // Object representing the database
  Ndb ndb( &cluster_connection, database_name);
  if (ndb.init()) APIERROR(ndb.getNdbError());

  /*
   * Do different operations on database
   */
  do_insert(ndb);
  do_read(ndb);
  do_cleanup(ndb);
}

int main(int argc, char** argv)
{
  if (argc != 3)
  {
    std::cout << "Arguments are <connect_string cluster> <database_name>.\n";
    exit(-1);
  }
  /* ndb_init must be called first */
  ndb_init();
  {
    /* connect to cluster */
    const char *connectstring = argv[1];
    Ndb_cluster_connection cluster_connection(connectstring);
    if (cluster_connection.connect(30 /* retries */,
                                   1  /* delay between retries */,
                                   0  /* verbose */))
    {
      std::cout << "Cluster management server was not ready within 30 secs.\n";
      exit(-1);
    }

    /* Connect and wait for the storage nodes */
    if (cluster_connection.wait_until_ready(30,10) < 0)
    {
      std::cout << "Cluster was not ready within 30 secs.\n";
      exit(-1);
    }

    /* run the application code */
    const char* dbname = argv[2];
    run_application(cluster_connection, dbname);
  }
  ndb_end(0);

  return 0;
}
```

Prior to NDB 8.0.1, this program could not be run more than once in succession during the same session (Bug #27009386).

2.5.12 NDB API Simple Array Example Using Adapter

This program inserts `CHAR`, `VARCHAR`, and `BINARY` column data into a table by constructing aRef objects using array adapters of the type defined in `common/array_adapter.hpp` (see Section 2.5.14, "Common Files for NDB API Array Examples"). It then reads the columns back and extracts the data, again using array adapters.

The example uses the table shown here:

```
CREATE TABLE api_array_using_adapter (
  ATTR1 INT UNSIGNED NOT NULL PRIMARY KEY,
  ATTR2 CHAR(20) NOT NULL,
  ATTR3 VARCHAR(20) NOT NULL,
  ATTR4 VARCHAR(500) NOT NULL,
  ATTR5 BINARY(20) NOT NULL,
  ATTR6 VARBINARY(20) NOT NULL,
  ATTR7 VARBINARY(500) NOT NULL
) ENGINE NDB CHARSET latin1;
```

The example file can be found as `ndbapi_array_using_adapter/ndbapi_array_using_adapter.cpp` in the NDB 7.3.8, NDB 7.4.3, or later NDB Cluster source distribution's `storage/ndb/ndbapi-examples` directory. (Bug #70550, Bug #17592990)

```
#include &lt;NdbApi.hpp&gt;
#include &lt;iostream&gt;
#include &lt;vector&gt;
#include &lt;cstdlib&gt;
#include &lt;cstring&gt;

using namespace std;

/*
  See Section 2.5.14, "Common Files for NDB API Array Examples",
  for listings of these utilities.
*/
#include "../common/error_handling.hpp"
#include "../common/array_adapter.hpp"
#include "../common/ndb_util.hpp"
#include "../common/util.hpp"


// Do a cleanup of all inserted rows
static void do_cleanup(Ndb& ndb)
{
  const NdbDictionary::Dictionary* dict = ndb.getDictionary();

  const NdbDictionary::Table *table = dict->getTable("api_array_using_adapter");
  if (table == nullptr) APIERROR(dict->getNdbError());

  NdbTransaction *transaction= ndb.startTransaction();
  if (transaction == nullptr) APIERROR(ndb.getNdbError());

  // Delete all 21 rows using a single transaction
  for (int i = 0; i <= 20; i++)
  {
    NdbOperation* myOperation = transaction->getNdbOperation(table);
    if (myOperation == nullptr) APIERROR(transaction->getNdbError());
    myOperation->deleteTuple();
    myOperation->equal("ATTR1", i);
  }

  if (transaction->execute(NdbTransaction::Commit) != 0)
  {
    APIERROR(transaction->getNdbError());
  }
  ndb.closeTransaction(transaction);
}
```

```
// Use one transaction and insert 21 rows in one batch.
static void do_insert(Ndb& ndb)
{
  const NdbDictionary::Dictionary* dict = ndb.getDictionary();
  const NdbDictionary::Table *table = dict->getTable("api_array_using_adapter");

  if (table == NULL)
  {
    APIERROR(dict->getNdbError());
  }

  // Get a column object for each CHAR/VARCHAR/BINARY/VARBINARY column
  // to insert into.
  const NdbDictionary::Column *column2 = table->getColumn("ATTR2");
  if (column2 == NULL)
  {
    APIERROR(dict->getNdbError());
  }

  const NdbDictionary::Column *column3 = table->getColumn("ATTR3");
  if (column3 == NULL)
  {
    APIERROR(dict->getNdbError());
  }

  const NdbDictionary::Column *column4 = table->getColumn("ATTR4");
  if (column4 == NULL)
  {
    APIERROR(dict->getNdbError());
  }

  const NdbDictionary::Column *column5 = table->getColumn("ATTR5");
  if (column5 == NULL)
  {
    APIERROR(dict->getNdbError());
  }

  const NdbDictionary::Column *column6 = table->getColumn("ATTR6");
  if (column6 == NULL)
  {
    APIERROR(dict->getNdbError());
  }

  const NdbDictionary::Column *column7 = table->getColumn("ATTR7");
  if (column7 == NULL)
  {
    APIERROR(dict->getNdbError());
  }

  // Create a read/write attribute adapter to be used for all
  // CHAR/VARCHAR/BINARY/VARBINARY columns.
  ReadWriteArrayAdapter attr_adapter;

  // Create and initialize sample data.
  const string meter = 50 * string("''''-,,,,|");
  unsigned char binary_meter[500];
  for (unsigned i = 0; i < 500; i++)
  {
    binary_meter[i] = (unsigned char)(i % 256);
  }

  NdbTransaction *transaction= ndb.startTransaction();
  if (transaction == NULL) APIERROR(ndb.getNdbError());

  // Create 21 operations and put a reference to them in a vector to
  // be able to find failing operations.
  vector<NdbOperation*> operations;
  for (int i = 0; i <= 20; i++)
  {
    NdbOperation* operation = transaction->getNdbOperation(table);
    if (operation == NULL) APIERROR(transaction->getNdbError());
```

```
    operation->insertTuple();

    operation->equal("ATTR1", i);

    /* use ReadWrite Adapter to convert string to aRefs */
    ReadWriteArrayAdapter::ErrorType error;

    char *attr2_aRef;
    attr2_aRef= attr_adapter.make_aRef(column2, meter.substr(0,i), error);
    PRINT_IF_NOT_EQUAL(error, ReadWriteArrayAdapter::Success,
                       "make_aRef failed for ATTR2");
    operation->setValue("ATTR2", attr2_aRef);

    char *attr3_aRef;
    attr3_aRef= attr_adapter.make_aRef(column3, meter.substr(0,i), error);
    PRINT_IF_NOT_EQUAL(error, ReadWriteArrayAdapter::Success,
                       "make_aRef failed for ATTR3");
    operation->setValue("ATTR3", attr3_aRef);

    char *attr4_aRef;
    attr4_aRef= attr_adapter.make_aRef(column4, meter.substr(0,20*i), error);
    PRINT_IF_NOT_EQUAL(error, ReadWriteArrayAdapter::Success,
                       "make_aRef failed for ATTR4");
    operation->setValue("ATTR4", attr4_aRef);

    char* attr5_aRef;
    char* attr5_first;
    attr_adapter.allocate_in_bytes(column5, attr5_aRef, attr5_first, i, error);
    PRINT_IF_NOT_EQUAL(error, ReadWriteArrayAdapter::Success,
                       "allocate_in_bytes failed for ATTR5");
    memcpy(attr5_first, binary_meter, i);
    operation->setValue("ATTR5", attr5_aRef);

    char* attr6_aRef;
    char* attr6_first;
    attr_adapter.allocate_in_bytes(column6, attr6_aRef, attr6_first, i, error);
    PRINT_IF_NOT_EQUAL(error, ReadWriteArrayAdapter::Success,
                       "allocate_in_bytes failed for ATTR6");
    memcpy(attr6_first, binary_meter, i);
    operation->setValue("ATTR6", attr6_aRef);

    char* attr7_aRef;
    char* attr7_first;
    attr_adapter.allocate_in_bytes(column7, attr7_aRef, attr7_first, 20*i, error);
    PRINT_IF_NOT_EQUAL(error, ReadWriteArrayAdapter::Success,
                       "allocate_in_bytes failed for ATTR7");
    memcpy(attr7_first, binary_meter, 20*i);
    operation->setValue("ATTR7", attr7_aRef);

    operations.push_back(operation);
  }

  // Now execute all operations in one batch, and check for errors.
  if (transaction->execute( NdbTransaction::Commit ) != 0)
  {
    for (size_t i = 0; i < operations.size(); i++)
    {
      const NdbError err= operations[i]->getNdbError();
      if(err.code != NdbError::Success)
      {
        cout << "Error inserting Row : " << i << endl;
        PRINT_ERROR(err.code, err.message);
      }
    }
    APIERROR(transaction->getNdbError());
  }
  ndb.closeTransaction(transaction);
}

/*
 Reads the row with id = 17
 Retrieves an prints value of the [VAR]CHAR/BINARY using array_adapter
```

```
 */
static void do_read(Ndb& ndb)
{
  const NdbDictionary::Dictionary* dict= ndb.getDictionary();
  const NdbDictionary::Table* table= dict->getTable("api_array_using_adapter");

  if (table == NULL) APIERROR(dict->getNdbError());

  NdbTransaction *transaction= ndb.startTransaction();
  if (transaction == NULL) APIERROR(ndb.getNdbError());

  NdbOperation *operation= transaction->getNdbOperation(table);
  if (operation == NULL) APIERROR(transaction->getNdbError());

  operation->readTuple(NdbOperation::LM_Read);
  operation->equal("ATTR1", 17);

  vector<NdbRecAttr*> attr;
  const int column_count= table->getNoOfColumns();
  attr.reserve(column_count);

  attr.push_back(nullptr);

  for (int i= 1; i < column_count; i++)
  {
    attr.push_back(operation->getValue(i, NULL));
    if (attr[i] == NULL) APIERROR(transaction->getNdbError());
  }

  if(transaction->execute( NdbTransaction::Commit ) == -1)
    APIERROR(transaction->getNdbError());

  /* Now use an array adapter to read the data from columns */
  const ReadOnlyArrayAdapter attr_adapter;
  ReadOnlyArrayAdapter::ErrorType error;

  /* print the fetched data */
  cout << "Row ID : 17\n";
  for (int i= 1; i < column_count; i++)
  {
    if (attr[i] != NULL)
    {
      NdbDictionary::Column::Type column_type = attr[i]->getType();
      cout << "Column id: " << i
           << ", name: " << attr[i]->getColumn()->getName()
           << ", size: " << attr[i]->get_size_in_bytes()
           << ", type: " << column_type_to_string(attr[i]->getType());
      if(attr_adapter.is_binary_array_type(column_type))
      {
        /* if column is [VAR]BINARY, get the byte array and print their sum */
        const char* data_ptr;
        size_t data_length;
        attr_adapter.get_byte_array(attr[i], data_ptr,
                                    data_length, error);
        if(error == ReadOnlyArrayAdapter::Success)
        {
          int sum = 0;
          for (size_t j = 0; j < data_length; j++)
            sum += (int)(data_ptr[j]);
          cout << ", stored bytes length: " << data_length
               << ", sum of byte array: " << sum << endl;
        }
        else
          cout << ", error fetching value." << endl;
      }
      else
      {
        /* if the column is [VAR]CHAR, retrieve the string and print */
        std::string value= attr_adapter.get_string(attr[i], error);
        if(error == ReadOnlyArrayAdapter::Success)
        {
          cout << ", stored string length: " << value.length()
```

```
              << ", value: " << value
              << endl;
        }
        else
          cout << ", error fetching value." << endl;
      }
    }
  }

  ndb.closeTransaction(transaction);
}

static void run_application(Ndb_cluster_connection &cluster_connection,
                            const char* database_name)
{
  /********************************************
   * Connect to database via NdbApi           *
   ********************************************/
  // Object representing the database
  Ndb ndb( &cluster_connection, database_name);
  if (ndb.init()) APIERROR(ndb.getNdbError());

  /*
   * Do different operations on database
   */
  do_insert(ndb);
  do_read(ndb);
  do_cleanup(ndb);
}

int main(int argc, char** argv)
{
  if (argc != 3)
  {
    std::cout << "Arguments are <connect_string cluster> <database_name>.\n";
    exit(-1);
  }
  /* ndb_init must be called first */
  ndb_init();
  {
    /* connect to cluster */
    const char *connectstring = argv[1];
    Ndb_cluster_connection cluster_connection(connectstring);
    if (cluster_connection.connect(30 /* retries */,
                                   1  /* delay between retries */,
                                   0  /* verbose */))
    {
      std::cout << "Cluster management server was not ready within 30 secs.\n";
      exit(-1);
    }

    /* Connect and wait for the storage nodes */
    if (cluster_connection.wait_until_ready(30,10) < 0)
    {
      std::cout << "Cluster was not ready within 30 secs.\n";
      exit(-1);
    }

    /* run the application code */
    const char* dbname = argv[2];
    run_application(cluster_connection, dbname);
  }
  ndb_end(0);

  return 0;
}
```

Prior to NDB 8.0.1, this program could not be run more than once in succession during the same session (Bug #27009386).

2.5.13 Timestamp2 Example

The file `timestamp2.cpp` reproduced in this section provides an example of working in NDB API applications with the “new” MySQL temporal data types supporting fractional seconds that were implemented in MySQL 5.6, and in NDB 7.3 and NDB 7.4.

For more information working with MySQL temporal and other data types in the NDB API, see Section 2.1.3.2, “NDB API Handling of MySQL Data Types”.

```
#include <stdio.h>
#include <stdlib.h>
#include <iostream>
#include <NdbApi.hpp>
#include <string>
#include <unistd.h>

//no binlog value
#define NDB_ANYVALUE_FOR_NOLOGGING 0x8000007f

using namespace std;

int setTimestamp(NdbOperation* op,
                 const NdbDictionary::Column* col,
                 unsigned int value)
{
  if (col->getType() == NDB_TYPE_TIMESTAMP)
  {
    /* Set as 32-bit int in host layout */
    return op->setValue(col->getName(), value);
  }
  else if (col->getType() == NDB_TYPE_TIMESTAMP2)
  {
    /* Set as 64 bit big-endian value */
    //assert(col->getPrecision() == 0);
    Uint64 ts = 0;
    unsigned char* bytes = (unsigned char*) &ts;
    bytes[0] = value >> 24 & 0xff;
    bytes[1] = value >> 16 & 0xff;
    bytes[2] = value >>  8 & 0xff;
    bytes[3] = value       & 0xff;
    return op->setValue(col->getName(), ts);
  }
  else
  {
    cout << "Bad type for column " << col->getType()
         << std::endl;
    exit(1);
  }
}

unsigned int readTimestamp(NdbRecAttr* recAttr)
{
  if (recAttr->getType() == NDB_TYPE_TIMESTAMP)
  {
    /* Timestamp is in native 32 bit layout */
    return recAttr->u_32_value();
  }
  else if (recAttr->getType() == NDB_TYPE_TIMESTAMP2)
  {
    /* Timestamp is in big-endian layout */
    //assert(recAttr->getColumn()->getPrecision() == 0);
    Uint64 ts2 = recAttr->u_64_value();
    const unsigned char* bytes = (const unsigned char*) &ts2;
    const unsigned int ts =
      (Uint64(bytes[0]) << 24) +
      (Uint64(bytes[1]) << 16) +
      (Uint64(bytes[2]) <<  8) +
      (Uint64(bytes[3]));

    return ts;
  }
```

```
  else
  {
    cout << "Error with timestamp column type : "
         << recAttr->getType()
         << endl;
    exit(1);
  }
}

void insert(string connectString)
{
    Ndb_cluster_connection *cluster_connection = new Ndb_cluster_connection(connectString.c_str());
    if(cluster_connection->connect(5,5,1)) {
        cout << "Cannot connect to Cluster using connectstring: "<< connectString << endl;
        exit(1);
    }

    if(cluster_connection->wait_until_ready(30,0) < 0) {
        cout << "Cluster was not ready within 30 seconds" << endl;
    }

    Ndb *myNdb = new Ndb(cluster_connection, "myndb_user_data");

    if(myNdb->init(1024) == -1){
        cout << "Error: Cannot initialize NDB object" << endl;
        exit(-1);
    }

    const NdbDictionary::Dictionary *dict = myNdb->getDictionary();
    if (dict == NULL) {
        cout << "Error: Cannot fetch NndDictionary" << endl;
        exit(0);
    }

    const NdbDictionary::Table *timestampTable = dict->getTable("TIMESTAMP_TEST");
    if (timestampTable == NULL) {
        cout << "Error: Cannot fetch MYNDB table" << endl;
        exit(0);
    }

    NdbTransaction *trans = myNdb->startTransaction();
    if (trans == NULL) {
      cout << "Error: Cannot start new transaction" << endl;
      exit(1);
    }

    NdbOperation *myOperation = trans->getNdbOperation(timestampTable);
    if ( myOperation == NULL) {
      cout << "Error: Cannot get new operation" << endl;
      exit(1);
    }

    myOperation->insertTuple();

    Uint64 value;
    myNdb->getAutoIncrementValue(timestampTable, value, (Uint32)32);
    myOperation->setValue("KEY_COL", value);


    time_t timestamp= time(NULL);
    setTimestamp(myOperation,
                 timestampTable->getColumn("createTimestamp"),
                 timestamp);
    setTimestamp(myOperation,
                 timestampTable->getColumn("modifyTimestamp"),
                 timestamp);
    //disable binlogging
    myOperation->setAnyValue(NDB_ANYVALUE_FOR_NOLOGGING);

    if(trans->execute(NdbTransaction::Commit) != 0) {
      cout << "Error: " << trans->getNdbError().message << endl;
      exit(1);
```

```
    }

    myNdb->closeTransaction(trans);

    delete myNdb;

    delete cluster_connection;
}


void fetch_from_database(string connectString)
{
    Ndb_cluster_connection *cluster_connection = new Ndb_cluster_connection(connectString.c_str());
    if(cluster_connection->connect(5,5,1)) {
        cout << "Cannot connect to Cluster using connectstring: "<< connectString << endl;
        exit(1);
    }

    if(cluster_connection->wait_until_ready(30,0) < 0) {
        cout << "Cluster was not ready within 30 seconds" << endl;
    }

    Ndb *myNdb = new Ndb(cluster_connection, "myndb_user_data");

    if(myNdb->init(1024) == -1){
        cout << "Error: Cannot initialize NDB object" << endl;
        exit(-1);
    }

    const NdbDictionary::Dictionary *dict = myNdb->getDictionary();
    if (dict == NULL) {
        cout << "Error: Cannot fetch NndDictionary" << endl;
        exit(0);
    }

    const NdbDictionary::Table *timestampTable = dict->getTable("TIMESTAMP_TEST");
    if (timestampTable == NULL) {
        cout << "Error: Cannot fetch MYNDB table" << endl;
        exit(0);
    }

    NdbTransaction *trans = myNdb->startTransaction();
    if (trans == NULL) {
      cout << "Error: Cannot start new transaction" << endl;
      exit(1);
    }

    NdbScanOperation *myOperation = trans->getNdbScanOperation(timestampTable);
    if ( myOperation == NULL) {
      cout << "Error: Cannot get new operation" << endl;
      exit(1);
    }

    if (myOperation->readTuples(NdbOperation::LM_Exclusive) == -1){
      cout << "Error: " << trans->getNdbError().message << endl;
      exit(0);
    }

    NdbRecAttr *recAttrs[3];
    recAttrs[0] = myOperation->getValue("KEY_COL");
    recAttrs[1] = myOperation->getValue("createTimestamp");
    recAttrs[2] = myOperation->getValue("modifyTimestamp");

    if (recAttrs[0] == NULL || recAttrs[1] == NULL || recAttrs[2] == NULL) {
        cout << "Error: " << trans->getNdbError().message << endl;
        exit(0);
    }

    if(trans->execute(NdbTransaction::NoCommit) != 0) {
      cout << "Error: " << trans->getNdbError().message << endl;
      exit(1);
    }
```

```
    int check;

    while((check = myOperation->nextResult(true)) == 0){
      do {
     cout << recAttrs[0]->u_32_value() << "\t";
            cout << readTimestamp(recAttrs[1]) << "\t";
     cout << readTimestamp(recAttrs[2]) << std::endl;
      }   while((check = myOperation->nextResult(false)) == 0);
    }

    myNdb->closeTransaction(trans);

    delete myNdb;

    delete cluster_connection;

}

int main(int argc, char **argv) {
 cout << "Timestamp test application!!!!" << endl;

 //fetch parameters
    string connectString;

    if (argc < 2) {
        cout<<"Please provide connect string for PLDB"<<endl;
        exit(1);
    }
    connectString = argv[1];

 ndb_init();

    insert(connectString);

    fetch_from_database(connectString);

 ndb_end(0);

 return EXIT_SUCCESS;
}
```

2.5.14 Common Files for NDB API Array Examples

In NDB 7.3.8, NDB 7.4.3, or later NDB Cluster source distribution, the `storage/ndb/ndbapi-examples` directory `storage/ndb/ndbapi-examples/common` contains four header files with utilities for use in example NDB API programs. (Bug #70550, Bug #17592990) The names of these files are listed here:

- `array_adapter.hpp`: Contains utility classes for converting between C++ style strings or byte arrays and the format used by NDB internally for `VARCHAR`, `CHAR`, and `VARBINARY` types.
- `error_handling.hpp`: Contains error handling functions.
- `ndb_util.hpp`: Defines a `column_type_to_string()` function which handles `NDB` column types.
- `util.hpp`: Provides a method for generating strings of arbitrary length.

Following in this section are source listings for each of the header files.

array_adapter.hpp

```
#ifndef ARRAY_ADAPTER_HPP
#define ARRAY_ADAPTER_HPP

#include <algorithm>
#include <assert.h>

/*
```

```
 Utility classes to convert between C++ strings/byte arrays and the
 internal format used for [VAR]CHAR/BINARY types.

 Base class that can be used for read operations. The column type is
 taken from the NdbRecAttr object, so only one object is needed to
 convert from different [VAR]CHAR/BINARY types. No additional memory
 is allocated.
 */
class ReadOnlyArrayAdapter {
public:
  ReadOnlyArrayAdapter() {}

  enum ErrorType {Success,
                  InvalidColumnType,
                  InvalidArrayType,
                  InvalidNullColumn,
                  InvalidNullAttribute,
                  InvalidNullaRef,
                  BytesOutOfRange,
                  UnknownError};

  /*
    Return a C++ string from the aRef() value of attr. This value
    will use the column and column type from attr. The advantage is
    for reading; the same ArrayAdapter can be used for multiple
    columns. The disadvantage is; passing an attribute not of
    [VAR]CHAR/BINARY type will result in a traditional exit(-1)
    */
  std::string get_string(const NdbRecAttr* attr,
                         ErrorType& error) const;

  /* Calculate the first_byte and number of bytes in aRef for attr */
  void get_byte_array(const NdbRecAttr* attr,
                      const char*& first_byte,
                      size_t& bytes,
                      ErrorType& error) const;

  /* Check if a column is of type [VAR]BINARY */
  bool is_binary_array_type(const NdbDictionary::Column::Type t) const;

  /* Check if a column is of type [VAR]BINARY or [VAR]CHAR */
  bool is_array_type(const NdbDictionary::Column::Type t) const;
private:
  /* Disable copy constructor */
  ReadOnlyArrayAdapter(const ReadOnlyArrayAdapter& a) {}
};


 /*
  Extension to ReadOnlyArrayAdapter to be used together with
  insert/write/update operations. Memory is allocated for each
  call to make_aRef or allocate_in_bytes. The memory allocated will
  be deallocated by the destructor. To save memory, the scope of an
  instance of this class should not be longer than the life time of
  the transaction. On the other hand, it must be long enough for the
  usage of all references created
  */
class ReadWriteArrayAdapter : public ReadOnlyArrayAdapter {
public:
  ReadWriteArrayAdapter() {}

  /* Destructor, the only place where memory is deallocated */
  ~ReadWriteArrayAdapter();

  /*
   Create a binary representation of the string 's' and return a
   pointer to it. This pointer can later be used as argument to for
   example setValue
   */
  char* make_aRef(const NdbDictionary::Column* column,
                  std::string s,
                  ErrorType& error);
```

```
  /*
   Allocate a number of bytes suitable for this column type. aRef
   can later be used as argument to for example setValue. first_byte
   is the first byte to store data to. bytes is the number of bytes
   to allocate
   */
  void allocate_in_bytes(const NdbDictionary::Column* column,
                         char*& aRef,
                         char*& first_byte,
                         size_t bytes,
                         ErrorType& error);

private:
  /* Disable copy constructor */
  ReadWriteArrayAdapter(const ReadWriteArrayAdapter& a)
    :ReadOnlyArrayAdapter() {}

  /* Record of allocated char arrays to delete by the destructor */
  std::vector<char*> aRef_created;
};


inline ReadWriteArrayAdapter::~ReadWriteArrayAdapter()
{
  for (std::vector<char*>::iterator i = aRef_created.begin();
       i != aRef_created.end();
       ++i) {
    delete [] *i;
  }
}


char*
ReadWriteArrayAdapter::
make_aRef(const NdbDictionary::Column* column,
          std::string input,
          ErrorType& error)
{
  char* new_ref;
  char* data_start;

  /*
   Allocate bytes and push them into the aRef_created vector.
   After this operation, new_ref has a complete aRef to use in insertion
   and data_start has ptr from which data is to be written.
   The new_aref returned is padded completely with blank spaces.
   */
  allocate_in_bytes(column, new_ref, data_start, input.length(), error);

  if(error != Success)
  {
    return NULL;
  }

  /*
   Copy the input string into aRef's data pointer
   without affecting remaining blank spaces at end.
   */
  strncpy(data_start, input.c_str(), input.length());

  return new_ref;
}


void
ReadWriteArrayAdapter::
allocate_in_bytes(const NdbDictionary::Column* column,
                  char*& aRef,
                  char*& first_byte,
                  size_t bytes,
                  ErrorType& error)
```

```
{
  bool is_binary;
  char zero_char;
  NdbDictionary::Column::ArrayType array_type;
  size_t max_length;

  /* unless there is going to be any problem */
  error = Success;

  if (column == NULL)
  {
    error = InvalidNullColumn;
    aRef = NULL;
    first_byte = NULL;
    return;
  }

  if (!is_array_type(column->getType()))
  {
    error = InvalidColumnType;
    aRef = NULL;
    first_byte = NULL;
    return;
  }

  is_binary = is_binary_array_type(column->getType());
  zero_char = (is_binary ? 0 : ' ');
  array_type = column->getArrayType();
  max_length = column->getLength();

  if (bytes > max_length)
  {
    error = BytesOutOfRange;
    aRef = NULL;
    first_byte = NULL;
    return;
  }

  switch (array_type) {
  case NdbDictionary::Column::ArrayTypeFixed:
    /* no need to store length bytes */
    aRef = new char[max_length];
    first_byte = aRef;
    /* pad the complete string with blank space (or) null bytes */
    for (size_t i=0; i < max_length; i++) {
      aRef[i] = zero_char;
    }
    break;
  case NdbDictionary::Column::ArrayTypeShortVar:
    /* byte length stored over first byte. no padding required */
    aRef = new char[1 + bytes];
    first_byte = aRef + 1;
    aRef[0] = (char)bytes;
    break;
  case NdbDictionary::Column::ArrayTypeMediumVar:
    /* byte length stored over first two bytes. no padding required */
    aRef = new char[2 + bytes];
    first_byte = aRef + 2;
    aRef[0] = (char)(bytes % 256);
    aRef[1] = (char)(bytes / 256);
    break;
  }
  aRef_created.push_back(aRef);
}


std::string ReadOnlyArrayAdapter::get_string(const NdbRecAttr* attr,
                                             ErrorType& error) const
{
  size_t attr_bytes= 0;
  const char* data_ptr= NULL;
  std::string result= "";
```

```
  /* get the beginning of data and its size.. */
  get_byte_array(attr, data_ptr, attr_bytes, error);

  if(error != Success)
  {
    return result;
  }

  /* ..and copy the  value into result */
  result = string(data_ptr, attr_bytes);

  /* special treatment for FixedArrayType to eliminate padding characters */
  if(attr->getColumn()->getArrayType() == NdbDictionary::Column::ArrayTypeFixed)
  {
    char padding_char = ' ';
    std::size_t last = result.find_last_not_of(padding_char);
    result = result.substr(0, last+1);
  }

  return result;
}


void
ReadOnlyArrayAdapter::
get_byte_array(const NdbRecAttr* attr,
               const char*& data_ptr,
               size_t& bytes,
               ErrorType& error) const
{
  /* unless there is a problem */
  error= Success;

  if (attr == NULL)
  {
    error = InvalidNullAttribute;
    return;
  }

  if (!is_array_type(attr->getType()))
  {
    error = InvalidColumnType;
    return;
  }

  const NdbDictionary::Column::ArrayType array_type =
      attr->getColumn()->getArrayType();
  const size_t attr_bytes = attr->get_size_in_bytes();
  const char* aRef = attr->aRef();

  if(aRef == NULL)
  {
    error= InvalidNullaRef;
    return;
  }

  switch (array_type) {
  case NdbDictionary::Column::ArrayTypeFixed:
    /* no length bytes stored with aRef */
    data_ptr = aRef;
    bytes = attr_bytes;
    break;
  case NdbDictionary::Column::ArrayTypeShortVar:
    /* first byte of aRef has length of the data */
    data_ptr = aRef + 1;
    bytes = (size_t)(aRef[0]);
    break;
  case NdbDictionary::Column::ArrayTypeMediumVar:
    /* first two bytes of aRef has length of the data */
    data_ptr = aRef + 2;
    bytes = (size_t)(aRef[1]) * 256 + (size_t)(aRef[0]);
```

```
    break;
  default:
    /* should never reach here */
    data_ptr = NULL;
    bytes = 0;
    error = InvalidArrayType;
    break;
  }
}


bool
ReadOnlyArrayAdapter::
is_binary_array_type(const NdbDictionary::Column::Type t) const
{
  bool is_binary;

  switch (t)
  {
  case NdbDictionary::Column::Binary:
  case NdbDictionary::Column::Varbinary:
  case NdbDictionary::Column::Longvarbinary:
    is_binary = true;
    break;
  default:
    is_binary = false;
  }
  return is_binary;
}


bool
ReadOnlyArrayAdapter::
is_array_type(const NdbDictionary::Column::Type t) const
{
  bool is_array;

  switch (t)
  {
  case NdbDictionary::Column::Binary:
  case NdbDictionary::Column::Varbinary:
  case NdbDictionary::Column::Longvarbinary:
  case NdbDictionary::Column::Char:
  case NdbDictionary::Column::Varchar:
  case NdbDictionary::Column::Longvarchar:
    is_array = true;
    break;
  default:
    is_array = false;
  }
  return is_array;
}

#endif // #ifndef ARRAY_ADAPTER_HPP
```

error_handling.hpp

```
#ifndef ERROR_HANDLING_HPP
#define ERROR_HANDLING_HPP

template <typename T>
inline static void print_if_not_equal(T got,
                                      T expected,
                                      const char* msg,
                                      const char* file,
                                      int line)
{
  std::cout << "Got value " << got << " instead of expected value " << expected
            << " in " << file << ":" << line;
}

#define PRINT_IF_NOT_EQUAL(got, expected, msg) {                        \
```

```
    if (got != expected) {                                              \
      print_if_not_equal(got, expected, msg, __FILE__, __LINE__);       \
      exit(-1);                                                         \
    }                                                                   \
  }

#define PRINT_ERROR(code,msg)                                           \
  std::cout << "Error in " << __FILE__ << ", line: " << __LINE__        \
            << ", code: " << code                                       \
            << ", msg: " << msg << "." << std::endl

#define APIERROR(error) {                \
  PRINT_ERROR(error.code,error.message); \
  exit(-1); }

#endif
```

ndb_util.hpp

```
#ifndef NDB_UTIL_HPP
#define NDB_UTIL_HPP

#include <NdbApi.hpp>
#include <string>
#include <sstream>

static const std::string column_type_to_string(NdbDictionary::Column::Type type)
{
  switch (type)
  {
  case NdbDictionary::Column::Undefined:
    return "Undefined";
  case NdbDictionary::Column::Tinyint:
    return "Tinyint";
  case NdbDictionary::Column::Tinyunsigned:
    return "Tinyunsigned";
  case NdbDictionary::Column::Smallint:
    return "Smallint";
  case NdbDictionary::Column::Smallunsigned:
    return "Smallunsigned";
  case NdbDictionary::Column::Mediumint:
    return "Mediumint";
  case NdbDictionary::Column::Mediumunsigned:
    return "Mediumunsigned";
  case NdbDictionary::Column::Int:
    return "Int";
  case NdbDictionary::Column::Unsigned:
    return "Unsigned";
  case NdbDictionary::Column::Bigint:
    return "Bigint";
  case NdbDictionary::Column::Bigunsigned:
    return "Bigunsigned";
  case NdbDictionary::Column::Float:
    return "Float";
  case NdbDictionary::Column::Double:
    return "Double";
  case NdbDictionary::Column::Olddecimal:
    return "Olddecimal";
  case NdbDictionary::Column::Olddecimalunsigned:
    return "Olddecimalunsigned";
  case NdbDictionary::Column::Decimal:
    return "Decimal";
  case NdbDictionary::Column::Decimalunsigned:
    return "Decimalunsigned";
  case NdbDictionary::Column::Char:
    return "Char";
  case NdbDictionary::Column::Varchar:
    return "Varchar";
  case NdbDictionary::Column::Binary:
    return "Binary";
  case NdbDictionary::Column::Varbinary:
    return "Varbinary";
```

```
  case NdbDictionary::Column::Datetime:
    return "Datetime";
  case NdbDictionary::Column::Date:
    return "Date";
  case NdbDictionary::Column::Blob:
    return "Blob";
  case NdbDictionary::Column::Text:
    return "Text";
  case NdbDictionary::Column::Bit:
    return "Bit";
  case NdbDictionary::Column::Longvarchar:
    return "Longvarchar";
  case NdbDictionary::Column::Longvarbinary:
    return "Longvarbinary";
  case NdbDictionary::Column::Time:
    return "Time";
  case NdbDictionary::Column::Year:
    return "Year";
  case NdbDictionary::Column::Timestamp:
    return "Timestamp";
  case NdbDictionary::Column::Time2:
    return "Time2";
  case NdbDictionary::Column::Datetime2:
    return "Datetime2";
  case NdbDictionary::Column::Timestamp2:
    return "Timestamp2";
  default:
    {
      std::string str;
      std::stringstream s(str);
      s << "Unknown type: " << type;
      return s.str();
    }
  }
}

#endif
```

util.hpp

```
#include <string>

/* Return a string containing 'n' copies of the string 's'. */
static std::string operator * (unsigned n, const std::string& s)
{
  std::string result;
  result.reserve(n * s.length());
  for (unsigned i = 0; i < n; i++)
  {
    result.append(s);
  }
  return result;
}

#endif // #ifndef UTIL_HPP
```

Chapter 3 The MGM API

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This chapter discusses the NDB Cluster Management API, a C language API that is used for administrative tasks such as starting and stopping Cluster nodes, backups, and logging. It also covers MGM API concepts, programming constructs, and event types.

3.1 MGM API Concepts

Each MGM API function needs a management server handle of type `NdbMgmHandle`. This handle is created by calling the function `ndb_mgm_create_handle()` and freed by calling `ndb_mgm_destroy_handle()`.

See Section 3.2.3.1, “ndb_mgm_create_handle()”, and Section 3.2.3.4, “ndb_mgm_destroy_handle()”, for more information about these two functions.

> **Important**
>
> You should not share an `NdbMgmHandle` between threads. While it is possible to do so (if you implement your own locks), this is not recommended; each thread should use its own management server handle.

A function can return any of the following:

- An integer value, with a value of `-1` indicating an error.
- A nonconstant pointer value. A `NULL` value indicates an error; otherwise, the return value must be freed by the programmer.
- A constant pointer value, with a `NULL` value indicating an error. The returned value should not be freed.

Error conditions can be identified by using the appropriate error-reporting functions `ndb_mgm_get_latest_error()` and `ndb_mgm_error()`.

Here is an example using the MGM API (without error handling for brevity's sake):

```
NdbMgmHandle handle= ndb_mgm_create_handle();
ndb_mgm_connect(handle,0,0,0);
struct ndb_mgm_cluster_state *state= ndb_mgm_get_status(handle);
for(int i=0; i < state->no_of_nodes; i++)
{
  struct ndb_mgm_node_state *node_state= &state->node_states[i];
  printf("node with ID=%d ", node_state->node_id);

  if(node_state->version != 0)
    printf("connected\n");
  else
    printf("not connected\n");
}
free((void*)state);
ndb_mgm_destroy_handle(&handle);
```

3.1.1 Working with Log Events

Data nodes and management servers regularly and on specific occasions report on various log events that occur in the cluster. These log events are written to the cluster log. Optionally an MGM API client may listen to these events using the method `ndb_mgm_listen_event()`. Each log event belongs to a category `ndb_mgm_event_category`) and has a severity `ndb_mgm_event_severity` associated with it. Each log event also has a level (0-15) associated with it.

Which log events that come out is controlled with `ndb_mgm_listen_event()`, `ndb_mgm_set_clusterlog_loglevel()`, and `ndb_mgm_set_clusterlog_severity_filter()`.

This is an example showing how to listen to events related to backup:

```
int filter[] = { 15, NDB_MGM_EVENT_CATEGORY_BACKUP, 0 };
int fd = ndb_mgm_listen_event(handle, filter);
```

3.1.2 Structured Log Events

The following steps are involved:

1. Create an `NdbLogEventHandle` using `ndb_mgm_create_logevent_handle()`.
2. Wait for and store log events using `ndb_logevent_get_next()`.
3. The log event data is available in the structure `ndb_logevent`. The data which is specific to a particular event is stored in a union between structures; use `ndb_logevent::type` to decide which structure is valid.

The following sample code demonstrates listening to events related to backups:

```
int filter[] = { 15, NDB_MGM_EVENT_CATEGORY_BACKUP, 0 };
NdbLogEventHandle le_handle= ndb_mgm_create_logevent_handle(handle, filter);
struct ndb_logevent le;
int r= ndb_logevent_get_next(le_handle, &le, 0);
if(r < 0)
  /*  error  */
else if(r == 0)
  /*  no event  */

switch(le.type)
{
  case NDB_LE_BackupStarted:
    ... le.BackupStarted.starting_node;
    ... le.BackupStarted.backup_id;
    break;
  case NDB_LE_BackupFailedToStart:
    ... le.BackupFailedToStart.error;
    break;
  case NDB_LE_BackupCompleted:
    ... le.BackupCompleted.stop_gci;
    break;
  case NDB_LE_BackupAborted:
    ... le.BackupStarted.backup_id;
    break;
  default:
    break;
}
```

For more information, see Section 3.2.1, “Log Event Functions”.

Available log event types are listed in Section 3.3.4, “The Ndb_logevent_type Type”, as well as in the file `/storage/ndb/include/mgmapi/ndb_logevent.h` in the NDB Cluster sources.

3.2 MGM API Function Listing

This section covers the structures and functions used in the MGM API. Listings are grouped by purpose or use.

3.2.1 Log Event Functions

This section discusses functions that are used for listening to log events.

3.2.1.1 ndb_mgm_listen_event()

Description. This function is used to listen to log events, which are read from the return file descriptor. Events use a text-based format, the same as in the cluster log.

Signature.

```
int ndb_mgm_listen_event
    (
      NdbMgmHandle handle,
      const int    filter[]
    )
```

Parameters. This function takes two arguments:

- An `NdbMgmHandle` *`handle`*.
- A *`filter`* which consists of a series of `{level, ndb_mgm_event_category}` pairs (in a single array) that are pushed to a file descriptor. Use `0` for the level to terminate the list.

Return value. The file descriptor from which events are to be read.

3.2.1.2 ndb_mgm_create_logevent_handle()

Description. This function is used to create a log event handle.

Signature.

```
NdbLogEventHandle ndb_mgm_create_logevent_handle
    (
      NdbMgmHandle handle,
      const int    filter[]
    )
```

Parameters. This function takes two arguments:

- An `NdbMgmHandle` *`handle`*.
- A *`filter`* which consists of a series of `{level, ndb_mgm_event_category}` pairs (in a single array) that are pushed to a file descriptor. Use `0` for the level to terminate the list.

Return value. A log event handle.

3.2.1.3 ndb_mgm_destroy_logevent_handle()

Description. Use this function to destroy a log event handle when there is no further need for it.

Signature.

```
void ndb_mgm_destroy_logevent_handle
    (
      NdbLogEventHandle* handle
    )
```

Parameters. A pointer to a log event *`handle`*.

Return value. *None*.

3.2.1.4 ndb_logevent_get_fd()

Description. This function retrieves a file descriptor from an `NdbMgmLogEventHandle`; this descriptor can be used in (for example) an application `select()` call.

Warning

Do not attempt to read from the file descriptor returned by this function; this can cause the descriptor to become corrupted.

Signature.

```
int ndb_logevent_get_fd
    (
      const NdbLogEventHandle handle
    )
```

Parameters. A `LogEventHandle`.

Return value. A file descriptor. In the event of failure, `-1` is returned.

3.2.1.5 ndb_logevent_get_next()

Description. This function is used to retrieve the next log event, using data from the event to fill in the supplied `ndb_logevent` structure.

Signature.

```
int ndb_logevent_get_next
```

```
    (
      const NdbLogEventHandle handle,
      struct ndb_logevent*    logevent,
      unsigned                timeout
    )
```

Important

Prior to NDB 7.3.2, the log event's `ndb_mgm_event_category` was cast to an `enum` type. This behavior, although incorrect, interfered with existing applications and was reinstated in NDB 7.3.7; a new function exhibiting the corrected behavior `ndb_logevent_get_next2()` was added in these releases.

Parameters. Three parameters are expected by this function:

- An `NdbLogEventHandle`
- A pointer to an `ndb_logevent` data structure
- The number of milliseconds to wait for the event before timing out; passing `0` for this parameter causes the function to block until the next log event is received

Return value. The value returned by this function is interpreted as follows: If the return value is less than or equal to zero, then the *`logevent`* is not altered or affected in any way.

- `> 0`: The event exists, and it data was retrieved into the *`logevent`*
- `0`: A timeout occurred while waiting for the event (more than *`timeout`* milliseconds elapsed)
- `< 0`: An error occurred.

3.2.1.6 ndb_logevent_get_next2()

Description. This function is used to retrieve the next log event, using data from the event to fill in the supplied `ndb_logevent` structure.

`ndb_logevent_get_next2()` was added in NDB 7.3.7. It is intended to serve as a replacement for `ndb_logevent_get_next()` which corrects that function's handling of the structure's `ndb_mgm_event_category`, for applications which do not require backward compatibility. It is otherwise identical to `ndb_logevent_get_next()`.

Signature.

```
int ndb_logevent_get_next2
    (
      const NdbLogEventHandle handle,
      struct ndb_logevent*    logevent,
      unsigned                timeout
    )
```

Parameters. Three parameters are expected by this function:

- An `NdbLogEventHandle`
- A pointer to an `ndb_logevent` data structure
- The number of milliseconds to wait for the event before timing out; passing `0` for this parameter causes the function to block until the next log event is received

Return value. The value returned by this function is interpreted as follows: If the return value is less than or equal to zero, then the *`logevent`* is not altered or affected in any way.

- `> 0`: The event exists, and it data was retrieved into the *`logevent`*

- `0`: A timeout occurred while waiting for the event (more than *`timeout`* milliseconds elapsed)
- `< 0`: An error occurred.

3.2.1.7 ndb_logevent_get_latest_error()

Description. This function retrieves the error code from the most recent error.

> **Note**
>
> You may prefer to use `ndb_logevent_get_latest_error_msg()` instead. See Section 3.2.1.8, "ndb_logevent_get_latest_error_msg()"

Signature.

```
int ndb_logevent_get_latest_error
    (
      const NdbLogEventHandle handle
    )
```

Parameters. A log event handle.

Return value. An error code.

3.2.1.8 ndb_logevent_get_latest_error_msg()

Description. Retrieves the text of the most recent error obtained while trying to read log events.

Signature.

```
const char* ndb_logevent_get_latest_error_msg
    (
      const NdbLogEventHandle handle
    )
```

Parameters. A log event handle.

Return value. The text of the error message.

3.2.2 MGM API Error Handling Functions

The MGM API functions used for error handling are discussed in this section.

Each MGM API error is characterised by an error code and an error message. There may also be an error description that may provide additional information about the error. The API provides functions to obtain this information in the event of an error.

3.2.2.1 ndb_mgm_get_latest_error()

Description. This function is used to get the latest error code associated with a given management server handle.

Prior to NDB 7.4.8, this function was not safe for use with `NULL`. In later versions, `ndb_mgm_get_latest_error()` is null-safe but returns an arbitrary value. (Bug #78130, Bug #21651706)

Signature.

```
int ndb_mgm_get_latest_error
    (
      const NdbMgmHandle handle
    )
```

Parameters. An `NdbMgMHandle`.

Return value. An error code corresponding to an `ndb_mgm_error` value. You can obtain the related error message using `ndb_mgm_get_latest_error_msg()`.

3.2.2.2 ndb_mgm_get_latest_error_msg()

Description. This function is used to obtain the latest general error message associated with an `NdbMgmHandle`.

Prior to NDB 7.4.8, this function was not safe for use with `NULL`. In later versions, `ndb_mgm_get_latest_error_msg()` is null-safe but returns an arbitrary value. (Bug #78130, Bug #21651706)

Signature.

```
const char* ndb_mgm_get_latest_error_msg
    (
      const NdbMgmHandle handle
    )
```

Parameters. An `NdbMgmHandle`.

Return value. The error message text. More specific information can be obtained using `ndb_mgm_get_latest_error_desc()`-

3.2.2.3 ndb_mgm_get_latest_error_desc()

Description. Get the most recent error description associated with an `NdbMgmHandle`; this description provides additional information regarding the error message.

Prior to NDB 7.4.8, this function was not safe for use with `NULL`. In later versions, `ndb_mgm_get_latest_error_desc()` is null-safe but returns an arbitrary value. (Bug #78130, Bug #21651706)

Signature.

```
const char* ndb_mgm_get_latest_error_desc
    (
      const NdbMgmHandle handle
    )
```

Parameters. An `NdbMgmHandle`.

Return value. The error description text.

3.2.2.4 ndb_mgm_set_error_stream()

Description. The function can be used to set the error output stream.

Signature.

```
void ndb_mgm_set_error_stream
    (
      NdbMgmHandle handle,
      FILE*        file
    )
```

Parameters. This function requires two parameters:

- An `NdbMgmHandle`
- A pointer to the file to which errors are to be sent.

Return value. *None*.

3.2.3 Management Server Handle Functions

This section contains information about the MGM API functions used to create and destroy management server handles.

3.2.3.1 ndb_mgm_create_handle()

Description. This function is used to create a handle to a management server.

Signature.

```
NdbMgmHandle ndb_mgm_create_handle
    (
      void
    )
```

Parameters. *None*.

Return value. An `NdbMgmHandle`.

3.2.3.2 ndb_mgm_set_name()

Description. This function can be used to set a name for the management server handle, which is then reported in the Cluster log.

Signature.

```
void ndb_mgm_set_name
    (
      NdbMgmHandle handle,
      const char*  name
    )
```

Parameters. This function takes two arguments:

- A management server *`handle`*.
- The desired *`name`* for the *`handle`*.

Return value. *None*.

3.2.3.3 ndb_mgm_set_ignore_sigpipe()

Description. The MGM API by default installs a signal handler that ignores all `SIGPIPE` signals that might occur when writing to asocket that has been closed or reset. An application that provides its own handler for `SIGPIPE` should call this function after creating the management server handle and before using the handle to connect to the management server. (In other words, call this function after using `ndb_mgm_create_handle()` but before calling `ndb_mgm_connect()`, which causes the MGM API's `SIGPIPE` handler to be installed unless overridden.)

Signature.

```
int ndb_mgm_set_ignore_sigpipe
    (
      NdbMgmHandle handle,
      int ignore = 1
    )
```

Parameters. This function takes two parameters:

- A management server handle
- An integer value which determines whether to *`ignore`* `SIGPIPE` errors. Set this to 1 (the default) to cause the MGM API to ignore `SIGPIPE`; set to zero if you wish for `SIGPIPE` to propagate to your MGM API application.

Return value. *None*.

3.2.3.4 ndb_mgm_destroy_handle()

Description. This function destroys a management server handle

Signature.

```
void ndb_mgm_destroy_handle
    (
      NdbMgmHandle* handle
    )
```

Parameters. A pointer to the `NdbMgmHandle` to be destroyed.

Return value. *None*.

3.2.4 Management Server Connection Functions

This section discusses MGM API functions that are used to initiate, configure, and terminate connections to an `NDB` management server.

3.2.4.1 ndb_mgm_get_connectstring()

Description. This function retrieves the connection string used for a connection.

Note

This function returns the default connection string if no call to `ndb_mgm_set_connectstring()` has been performed. In addition, the returned connection string may be formatted slightly differently than the original in that it may contain specifiers not present in the original.

The connection string format is the same as that discussed for Section 3.2.4.10, "ndb_mgm_set_connectstring()".

Signature.

```
const char* ndb_mgm_get_connectstring
    (
      NdbMgmHandle handle,
      char*        buffer,
      int          size
    )
```

Parameters. This function takes three arguments:

- An `NdbMgmHandle`.
- A pointer to a *`buffer`* in which to place the result.
- The *`size`* of the buffer.

Return value. The connection string—this is the same value that is pushed to the *`buffer`*.

3.2.4.2 ndb_mgm_get_configuration_nodeid()

Description. This function gets the ID of the node to which the connection is being (or was) made.

Signature.

```
int ndb_mgm_get_configuration_nodeid
    (
```

```
      NdbMgmHandle handle
    )
```

Parameters. A management server handle.

Return value. A node ID.

3.2.4.3 ndb_mgm_get_connected_port()

Description. This function retrieves the number of the port used by the connection.

Signature.

```
int ndb_mgm_get_connected_port
    (
      NdbMgmHandle handle
    )
```

Parameters. An `NdbMgmHandle`.

Return value. A port number.

3.2.4.4 ndb_mgm_get_connected_host()

Description. This function is used to obtain the name of the host to which the connection is made.

Signature.

```
const char* ndb_mgm_get_connected_host
    (
      NdbMgmHandle handle
    )
```

Parameters. A management server *`handle`*.

Return value. A host name.

3.2.4.5 ndb_mgm_get_version()

Description. Given a management server handle, this function gets `NDB` engine and MySQL Server version information for the indicated management server.

Signature.

```
int ndb_mgm_get_version
    (
      NdbMgmHandle handle,
      int* major,
      int* minor,
      int* build,
      int length,
      char* string
    )
```

Parameters. An `NdbMgmHandle`, and pointers to the `NDB` engine *`major`*, *`minor`*, and *`build`* version values, as well as a pointer to the version *`string`* (along with the strength's *`length`*).

The version string uses the format `mysql-x.x.x ndb-y.y.y-status`, where *`x.x.x`* is the three-part MySQL Server version, and *`y.y.y`* is the three-part `NDB` storage engine version. The *`status`* string indicates the release level or status; usually this is one of `beta`, `rc`, or `ga`, but other values are sometimes possible.

Return value. `ndb_mgm_get_version()` returns an integer: 0 on success; any nonzero value indicates an error.

3.2.4.6 ndb_mgm_is_connected()

Description. Used to determine whether a connection has been established.

> **Note**
>
> This function does not determine whether or not there is a “live” management server at the other end of the connection. Use `ndb_mgm_check_connection()` to accomplish that task.

Signature.

```
int ndb_mgm_is_connected
    (
      NdbMgmHandle handle
    )
```

Parameters. A management server *handle*.

Return value. This function returns an integer, whose value is interpreted as follows:

- `0`: Not connected to the management node.
- Any nonzero value: A connection has been established with the management node.

3.2.4.7 ndb_mgm_check_connection()

Description. This function can be used to determine whether a management server is running on a given connection from a management client.

Signature.

```
int ndb_mgm_check_connection
    (
      NdbMgmHandle handle
    )
```

Parameters. An `NdbMgmHandle` (see Section 3.1, “MGM API Concepts”).

Return value. In NDB 7.5 and later, this function returns 0 on success, -1 when the handle is null, and -2 when not connected.

In NDB 7.4 and earlier, this function returned -1 in the event of an error; otherwise it returned 0, even when the management server handle was NULL, or when the connection check failed (Bug #53242, Bug #11760802).

3.2.4.8 ndb_mgm_number_of_mgmd_in_connect_string()

Description. This is a convenience function which provides an easy way to determine the number of management servers referenced in a connection string as set using `ndb_mgm_set_connectstring()`.

Signature.

```
int ndb_mgm_number_of_mgmd_in_connect_string
    (
      NdbMgmHandle handle
    )
```

Parameters. A management handle (`NdbMgmHandle`).

Return value. On success, a nonnegative integer; a negative integer indicates failure.

3.2.4.9 ndb_mgm_set_bindaddress()

Description. This function makes it possible to set a local bind address for the management server. If used, it must be called before connecting to the management server.

Signature.

```
int ndb_mgm_set_bindaddress
    (
      NdbMgmHandle handle,
      const char*  address
    )
```

Parameters. This function takes two parameters:

- A management handle (`NdbMgmHandle`).
- A string *`address`* of the form *`host[:port]`*.

Return value. Returns an integer:

- `0` indicates success
- Any nonzero value indicates failure (the address was not valid)

Important

Errors caused by binding an otherwise valid local address are not reported until the connection to the management is actually attempted.

3.2.4.10 ndb_mgm_set_connectstring()

Description. This function is used to set the connection string for a management server connection to a node.

Signature.

```
int ndb_mgm_set_connectstring
    (
      NdbMgmHandle handle,
      const char*  connection_string
    )
```

Parameters. `ndb_mgm_set_connectstring()` takes two parameters:

- A management server *`handle`*.
- A *`connection_string`* whose format is shown here:

  ```
  connection_string :=
      [nodeid-specification,]host-specification[,host-specification]
  ```

  `ndb_mgm_get_connectstring()` also uses this format for connection strings.

  It is possible to establish connections with multiple management servers using a single connection string.

  ```
  nodeid-specification := nodeid=id
  host-specification := host[:port]
  ```

  `id`, *`port`*, and *`host`* are defined as follows:

  - *`id`*: An integer greater than `0` identifying a node in `config.ini`.
  - *`port`*: An integer referring to a standard Unix port.
  - *`host`*: A string containing a valid network host address.

Return value. This function returns `-1` in the event of failure.

3.2.4.11 ndb_mgm_set_configuration_nodeid()

Description. This function sets the connection node ID.

Signature.

```
int ndb_mgm_set_configuration_nodeid
    (
      NdbMgmHandle handle,
      int          id
    )
```

Parameters. This function requires two parameters:

- An `NdbMgmHandle`.
- The `id` of the node to connect to.

Return value. This function returns `-1` in the event of failure.

3.2.4.12 ndb_mgm_set_timeout()

Description. Normally, network operations time out after 60 seconds. This function permits you to vary this time.

> **Important**
>
> The timeout set by this function applies not only to establishing network connections, but to *every* operation requiring communication using a network connection. This includes each network read or write performed by any MGM API function, NDB API method call, or `ndb_mgm` client command.

Signature.

```
int ndb_mgm_set_timeout
    (
      NdbMgmHandle handle,
      unsigned int timeout
    )
```

Parameters. This function takes two parameters:

- A management server handle (`NdbMgmHandle`).
- An amount of time to wait before timing out, expressed in milliseconds.

Return value. Returns `0` on success, with any other value representing failure.

3.2.4.13 ndb_mgm_connect()

Description. This function establishes a connection to a management server specified by the connection string set by Section 3.2.4.10, “ndb_mgm_set_connectstring()”.

Signature.

```
int ndb_mgm_connect
    (
      NdbMgmHandle handle,
      int          retries,
      int          delay,
      int          verbose
    )
```

Parameters. This function takes 4 arguments:

- A management server *handle*.
- The number of retries to make when attempting to connect. 0 for this value means that one connection attempt is made.
- The number of seconds to *delay* between connection attempts.
- If *verbose* is 1, then a message is printed for each connection attempt.

Return value. This function returns -1 in the event of failure.

3.2.4.14 ndb_mgm_disconnect()

Description. This function terminates a management server connection.

Signature.

```
int ndb_mgm_disconnect
    (
      NdbMgmHandle handle
    )
```

Parameters. An NdbMgmHandle.

Return value. Returns -1 if unable to disconnect.

3.2.5 Cluster Status Functions

This section discusses how to obtain status information from NDB Cluster nodes.

3.2.5.1 ndb_mgm_get_status()

Description. This function is used to obtain the status of the nodes in an NDB Cluster.

Note

The caller must free the pointer returned by this function.

Signature.

```
struct ndb_mgm_cluster_state* ndb_mgm_get_status
    (
      NdbMgmHandle handle
    )
```

Parameters. This function takes a single parameter, a management server *handle*.

Return value. A pointer to an ndb_mgm_cluster_state data structure.

3.2.5.2 ndb_mgm_get_status2()

Description. This function is similar to ndb_mgm_get_status(), in that it is used to obtain the status of the nodes in an NDB Cluster. However, ndb_mgm_get_status2() allows one to specify the type or types of nodes (ndb_mgm_node_type) to be checked.

Note

The caller must free the pointer returned by this function.

Signature.

```
struct ndb_mgm_cluster_state* ndb_mgm_get_status2
    (
      NdbMgmHandle handle,
      const enum ndb_mgm_node_type types[]
    )
```

Parameters. This function takes two parameters:

- A management server *handle*
- A pointer to array of the node types to be checked. These are `ndb_mgm_node_type` values. The array should be terminated by an element of type `NDB_MGM_NODE_TYPE_UNKNOWN`.

Return value. A pointer to an `ndb_mgm_cluster_state` data structure.

3.2.5.3 ndb_mgm_dump_state()

Description. This function can be used to dump debugging information to the cluster log. The NDB Cluster management client `DUMP` command is a wrapper for this function.

Important

`ndb_mgm_dump_state()`, like the `DUMP` command, can cause a running NDB Cluster to malfunction or even to fail completely if it is used improperly. Be sure to consult the relevant documentation before using this function. For more information on the `DUMP` command, and for a listing of current `DUMP` codes and their effects, see NDB Cluster Management Client DUMP Commands.

Signature.

```
int ndb_mgm_dump_state
    (
      NdbMgmHandle handle,
      int nodeId,
      const int* arguments,
      int numberOfArguments,
      struct ndb_mgm_reply* reply
    )
```

Parameters. This function takes the following pararemeters:

- A management server handle (`NdbMgmHandle`)
- The *nodeId* of a cluster data node.
- An array of *arguments*. The first of these is the `DUMP` code to be executed. Subsequent arguments can be passed in this array if needed by or desired for the corresponding `DUMP` command.
- The *numberOfArguments* to be passed.
- An `ndb_mgm_reply`, which contains a return code along with a response or error message.

Return value. `0` on success; otherwise, an error code.

Example. The following example has the same result as running `2 DUMP 1000` in the management client:

```
//  [...]
#include <mgmapi_debug.h>
//  [...]
struct ndb_mgm_reply reply;
int args[1];
int stat, arg_count, node_id;

args[0] = 1000;
```

```
arg_count = 1;
node_id = 2;

stat = ndb_mgm_dump_state(h, node_id, args, arg_count, &reply);
```

3.2.6 Functions for Starting & Stopping Nodes

The MGM API provides several functions which can be used to start, stop, and restart one or more Cluster data nodes. These functions are discussed in this section.

Starting, Stopping, and Restarting Nodes. You can start, stop, and restart Cluster nodes using the following functions, which are described in more detail in the next few sections.

- **Starting Nodes.** Use `ndb_mgm_start()`.
- **Stopping Nodes.** Use `ndb_mgm_stop()`, `ndb_mgm_stop2()`, `ndb_mgm_stop3()`, or `ndb_mgm_stop4()`.

  Normally, you cannot use any of these functions to stop a node while other nodes are starting. You can override this restriction using `ndb_mgm_stop4()` with the *`force`* parameter set to 1.
- **Restarting Nodes.** Use `ndb_mgm_restart()`, `ndb_mgm_restart2()`, `ndb_mgm_restart3()`, or `ndb_mgm_restart4()`.

  Normally, you cannot use any of these functions to restart a node while other nodes are starting. You can override this restriction using `ndb_mgm_restart4()` with the *`force`* parameter set to 1.

3.2.6.1 ndb_mgm_start()

Description. This function can be used to start one or more Cluster nodes. The nodes to be started must have been started with the no-start option (`-n`), meaning that the data node binary was started and is waiting for a `START` management command which actually enables the node.

Signature.

```
int ndb_mgm_start
    (
      NdbMgmHandle handle,
      int          number,
      const int*   list
    )
```

Parameters. `ndb_mgm_start()` takes 3 parameters:

- An `NdbMgmHandle`.
- A *`number`* of nodes to be started. Use `0` to start all of the data nodes in the cluster.
- A *`list`* of the node IDs of the nodes to be started.

Return value. The number of nodes actually started; in the event of failure, `-1` is returned.

3.2.6.2 ndb_mgm_stop()

Description. This function stops one or more data nodes.

Signature.

```
int ndb_mgm_stop
    (
      NdbMgmHandle handle,
      int          number,
      const int*   list
    )
```

Parameters. `ndb_mgm_stop()` takes 3 parameters: Calling this function is equivalent to calling `ndb_mgm_stop2(handle, number, list, 0)`.

- An `NdbMgmHandle`.
- The *`number`* of nodes to be stopped. Use `0` to stop all of the data nodes in the cluster.
- A *`list`* of the node IDs of the nodes to be stopped.

Return value. The number of nodes actually stopped; in the event of failure, `-1` is returned.

3.2.6.3 ndb_mgm_stop2()

Description. Like `ndb_mgm_stop()`, this function stops one or more data nodes. However, it offers the ability to specify whether or not the nodes shut down gracefully.

Signature.

```
int ndb_mgm_stop2
    (
      NdbMgmHandle handle,
      int          number,
      const int*   list,
      int          abort
    )
```

Parameters. `ndb_mgm_stop2()` takes 4 parameters:

- An `NdbMgmHandle`.
- The *`number`* of nodes to be stopped. Use `0` to stop all of the data nodes in the cluster.
- A *`list`* of the node IDs of the nodes to be stopped.
- The value of *`abort`* determines how the nodes will be shut down. `1` indicates the nodes will shut down immediately; `0` indicates that the nodes will stop gracefully.

Return value. The number of nodes actually stopped; in the event of failure, `-1` is returned.

3.2.6.4 ndb_mgm_stop3()

Description. Like `ndb_mgm_stop()` and `ndb_mgm_stop2()`, this function stops one or more data nodes. Like `ndb_mgm_stop2()`, it offers the ability to specify whether the nodes should shut down gracefully. In addition, it provides for a way to check to see whether disconnection is required prior to stopping a node.

Signature.

```
int ndb_mgm_stop3
    (
      NdbMgmHandle handle,
      int          number,
      const int*   list,
      int          abort,
      int*         disconnect
    )
```

Parameters. `ndb_mgm_stop3()` takes 5 parameters:

- An `NdbMgmHandle`.
- The *`number`* of nodes to be stopped. Use `0` to stop all of the data nodes in the cluster.
- A *`list`* of the node IDs of the nodes to be stopped.

- The value of *abort* determines how the nodes will be shut down. `1` indicates the nodes will shut down immediately; `0` indicates that the nodes will stop gracefully.
- If *disconnect* returns `1` (`true`), this means the you must disconnect before you can apply the command to stop. For example, disconnecting is required when stopping the management server to which the handle is connected.

Return value. The number of nodes actually stopped; in the event of failure, `-1` is returned.

3.2.6.5 ndb_mgm_stop4()

Description. Like the other `ndb_mgm_stop*()` functions, this function stops one or more data nodes. Like `ndb_mgm_stop2()`, it offers the ability to specify whether the nodes should shut down gracefully; like `ndb_mgm_stop3()` it provides for a way to check to see whether disconnection is required prior to stopping a node. In addition, it is possible to force the node to shut down even if this would cause the cluster to become nonviable.

Signature.

```
int ndb_mgm_stop4
    (
      NdbMgmHandle handle,
      int          number,
      const int*   list,
      int          abort,
      int          force,
      int*         disconnect
    )
```

Parameters. `ndb_mgm_stop4()` takes 6 parameters:

- An `NdbMgmHandle`.
- The *number* of nodes to be stopped. Use `0` to stop all of the data nodes in the cluster.
- A *list* of the node IDs of the nodes to be stopped.
- The value of *abort* determines how the nodes will be shut down. `1` indicates the nodes will shut down immediately; `0` indicates that the nodes will stop gracefully.
- The value of *force* determines the action to be taken in the event that the shutdown of a given node would cause an incomplete cluster. `1` causes the node—and the entire cluster—to be shut down in such cases, `0` means the node will not be shut down.

  Setting *force* equal to 1 also makes it possible to stop a node even while other nodes are starting. (Bug #58451)
- If *disconnect* returns `1` (`true`), this means the you must disconnect before you can apply the command to stop. For example, disconnecting is required when stopping the management server to which the handle is connected.

Return value. The number of nodes actually stopped; in the event of failure, `-1` is returned.

3.2.6.6 ndb_mgm_restart()

Description. This function can be used to restart one or more Cluster data nodes.

Signature.

```
int ndb_mgm_restart
    (
      NdbMgmHandle handle,
      int          number,
      const int*   list
```

```
    )
```

Parameters. `ndb_mgm_restart()` takes 3 parameters:

- An `NdbMgmHandle`.
- The *`number`* of nodes to be stopped. Use `0` to stop all of the data nodes in the cluster.
- A *`list`* of the node IDs of the nodes to be stopped.

Calling this function is equivalent to calling

```
ndb_mgm_restart2(handle, number, list, 0, 0, 0);
```

See Section 3.2.6.7, “ndb_mgm_restart2()”, for more information.

Return value. The number of nodes actually restarted; `-1` on failure.

3.2.6.7 ndb_mgm_restart2()

Description. Like `ndb_mgm_restart()`, this function can be used to restart one or more Cluster data nodes. However, `ndb_mgm_restart2()` provides additional restart options, including initial restart, waiting start, and immediate (forced) restart.

Signature.

```
int ndb_mgm_restart2
    (
      NdbMgmHandle handle,
      int          number,
      const int*   list,
      int          initial
      int          nostart,
      int          abort
    )
```

Parameters. `ndb_mgm_restart2()` takes 6 parameters:

- An `NdbMgmHandle`.
- The *`number`* of nodes to be stopped. Use `0` to stop all of the data nodes in the cluster.
- A *`list`* of the node IDs of the nodes to be stopped.
- If *`initial`* is true (`1`), then each node undergoes an initial restart—that is, its file system is removed.
- If `nostart` is true, then the nodes are not actually started, but instead are left ready for a start command.
- If *`abort`* is true, then the nodes are restarted immediately, bypassing any graceful restart.

Return value. The number of nodes actually restarted; `-1` on failure.

3.2.6.8 ndb_mgm_restart3()

Description. Like `ndb_mgm_restart2()`, this function can be used to cause an initial restart, waiting restart, and immediate (forced) restart on one or more Cluster data nodes. However, `ndb_mgm_restart3()` provides the additional options of checking whether disconnection is required prior to the restart.

Signature.

```
int ndb_mgm_restart3
```

```
    (
      NdbMgmHandle handle,
      int          number,
      const int*   list,
      int          initial
      int          nostart,
      int          abort,
      int*         disconnect
    )
```

Parameters. `ndb_mgm_restart3()` takes 7 parameters:

- An `NdbMgmHandle`.
- The *`number`* of nodes to be stopped. Use `0` to stop all of the data nodes in the cluster.
- A *`list`* of the node IDs of the nodes to be stopped.
- If *`initial`* is true (`1`), then each node undergoes an initial restart—that is, its file system is removed.
- If `nostart` is true, then the nodes are not actually started, but instead are left ready for a start command.
- If *`abort`* is true, then the nodes are forced to restart immediately without performing a graceful restart.
- If *`disconnect`* returns `1` (`true`), this means the you must disconnect before you can apply the command to restart. For example, disconnecting is required when stopping the management server to which the handle is connected.

Return value. The number of nodes actually restarted; `-1` on failure.

3.2.6.9 ndb_mgm_restart4()

Description. Like the other `ndb_mgm_restart*()` functions, this function restarts one or more data nodes. Like `ndb_mgm_restart2()`, it can be used to cause an initial restart, waiting restart, and immediate (forced) restart on one or more NDB Cluster data nodes; like `ndb_mgm_stop3()` it provides for a way to check to see whether disconnection is required prior to stopping a node. In addition, it is possible to force the node to restart even if this would cause a restart of the cluster.

Signature.

```
int ndb_mgm_restart4
    (
      NdbMgmHandle handle,
      int          number,
      const int*   list,
      int          initial
      int          nostart,
      int          abort,
      int          force,
      int*         disconnect
    )
```

Parameters. `ndb_mgm_restart4()` takes 7 parameters:

- An `NdbMgmHandle`.
- The *`number`* of nodes to be stopped. Use `0` to stop all of the data nodes in the cluster.
- A *`list`* of the node IDs of the nodes to be stopped.
- If *`initial`* is true (`1`), then each node undergoes an initial restart—that is, its file system is removed.

- If `nostart` is true, then the nodes are not actually started, but instead are left ready for a start command.
- If *`abort`* is true, then the nodes are forced to restart immediately without performing a graceful restart.
- The value of *`force`* determines the action to be taken in the event that the loss of a given node due to restarting would cause an incomplete cluster.

  `1` causes the node—and the entire cluster—to be restarted in such cases, `0` means that the node will not be restarted.

  Setting *`force`* equal to 1 also makes it possible to restart a node even while other nodes are starting. (Bug #58451)
- If *`disconnect`* returns `1` (`true`), this means the you must disconnect before you can apply the command to restart. For example, disconnecting is required when stopping the management server to which the handle is connected.

Return value. The number of nodes actually restarted; `-1` on failure.

3.2.7 Cluster Log Functions

This section covers the functions available in the MGM API for controlling the output of the cluster log.

3.2.7.1 ndb_mgm_get_clusterlog_severity_filter()

Description. This function is used to retrieve the cluster log severity filter currently in force.

Signature.

```
int ndb_mgm_get_clusterlog_severity_filter
    (
      NdbMgmHandle handle,
      struct ndb_mgm_severity* severity,
      unsigned int size
    )
```

Parameters.

- An `NdbMgmHandle`.
- A vector *`severity`* of seven (`NDB_MGM_EVENT_SEVERITY_ALL`) elements, each of which is an `ndb_mgm_severity` structure, where each element contains `1` if a severity indicator is enabled and `0` if not. A severity level is stored at position *`ndb_mgm_clusterlog_level`*; for example the error level is stored at position `NDB_MGM_EVENT_SEVERITY_ERROR`. The first element (position `NDB_MGM_EVENT_SEVERITY_ON`) in the vector signals whether the cluster log is disabled or enabled.
- The *`size`* of the vector (`NDB_MGM_EVENT_SEVERITY_ALL`).

Return value. The number of returned severities, or `-1` in the event of an error.

3.2.7.2 ndb_mgm_set_clusterlog_severity_filter()

Description. This function is used to set a cluster log severity filter.

Signature.

```
int ndb_mgm_set_clusterlog_severity_filter
    (
      NdbMgmHandle                handle,
      enum ndb_mgm_event_severity severity,
```

```
      int                         enable,
      struct ndb_mgm_reply*       reply
    )
```

Parameters. This function takes 4 parameters:

- A management server *handle*.
- A cluster log *severity* to filter.
- A flag to *enable* or disable the filter; 1 enables and 0 disables the filter.
- A pointer to an ndb_mgm_reply structure for a reply message.

Return value. The function returns -1 in the event of failure.

3.2.7.3 ndb_mgm_get_clusterlog_loglevel()

Description. This function is used to obtain log category and level information, and is thread-safe.

Signature.

```
int ndb_mgm_get_clusterlog_loglevel
    (
      NdbMgmHandle handle,
      struct ndb_mgm_loglevel* loglevel,
      unsigned int size
    )
```

Parameters. ndb_mgm_get_clusterlog_loglevel() takes the following parameters:

- A management *handle* (NdbMgmHandle).
- A *loglevel* (log level) vector consisting of twelve elements, each of which is an ndb_mgm_loglevel structure and which represents a log level of the corresponding category.
- The *size* of the vector (MGM_LOGLEVELS).

Return value. This function returns the number of returned loglevels or -1 in the event of an error.

3.2.7.4 ndb_mgm_set_clusterlog_loglevel()

Description. This function is used to set the log category and levels for the cluster log.

Signature.

```
int ndb_mgm_set_clusterlog_loglevel
    (
      NdbMgmHandle                handle,
      int                         id,
      enum ndb_mgm_event_category category,
      int                         level,
      struct ndb_mgm_reply*       reply)
```

Parameters. This function takes 5 parameters:

- An NdbMgmHandle.
- The *id* of the node affected.
- An event *category*mdash;this is one of the values listed in Section 3.3.7, “The ndb_mgm_event_category Type” .
- A logging *level*.
- A pointer to an ndb_mgm_reply structure for the *reply* message.

Return value. In the event of an error, this function returns `-1`.

3.2.8 Backup Functions

This section covers the functions provided in the MGM API for starting and stopping backups.

3.2.8.1 ndb_mgm_start_backup()

Description. This function is used to initiate a backup of an NDB Cluster.

Signature.

```
int ndb_mgm_start_backup
    (
      NdbMgmHandle          handle,
      int                   wait,
      unsigned int*         id,
      struct ndb_mgm_reply* reply
    )
```

Parameters. This function requires 4 parameters:

- A management server *`handle`* (an `NdbMgmHandle`).
- A *`wait`* flag, with the following possible values:
  - `0`: Do not wait for confirmation of the backup.
  - `1`: Wait for the backup to be started.
  - `2`: Wait for the backup to be completed.
- A backup *`id`* to be returned by the function.

Note

No backup *`id`* is returned if *`wait`* is set equal to 0.

- A pointer to an `ndb_mgm_reply` structure to accommodate a *`reply`*.

Return value. In the event of failure, the function returns `-1`.

3.2.8.2 ndb_mgm_abort_backup()

Description. This function is used to stop a Cluster backup.

Signature.

```
int ndb_mgm_abort_backup
    (
      NdbMgmHandle          handle,
      unsigned int          id,
      struct ndb_mgm_reply* reply)
```

Parameters. This function takes 3 parameters:

- An `NdbMgmHandle`.
- The *`id`* of the backup to be aborted.
- A pointer to an `ndb_mgm_reply` structure.

Return value. In case of an error, this function returns `-1`.

3.2.9 Single-User Mode Functions

The MGM API makes it possible for the programmer to put the cluster into single-user mode—and to return it to normal mode again—from within an application. This section covers the functions that are used for these operations.

3.2.9.1 ndb_mgm_enter_single_user()

Description. This function is used to enter single-user mode on a given node.

Signature.

```
int ndb_mgm_enter_single_user
    (
      NdbMgmHandle          handle,
      unsigned int          id,
      struct ndb_mgm_reply* reply
    )
```

Parameters. This function takes 3 parameters:

- An `NdbMgmHandle`.
- The *`id`* of the node to be used in single-user mode.
- A pointer to an `ndb_mgm_reply` structure, used for a *`reply`* message.

Return value. Returns `-1` in the event of failure.

3.2.9.2 ndb_mgm_exit_single_user()

Description. This function is used to exit single-user mode and to return to normal operation.

Signature.

```
int ndb_mgm_exit_single_user
    (
      NdbMgmHandle          handle,
      struct ndb_mgm_reply* reply
    )
```

Parameters. This function requires 2 arguments:

- An `NdbMgmHandle`.
- A pointer to an `ndb_mgm_reply`.

Return value. Returns `-1` in case of an error.

3.3 MGM API Data Types

This section discusses the data types defined by the MGM API.

> **Note**
>
> The types described in this section are all defined in the file `/storage/ndb/include/mgmapi/mgmapi.h`, with the exception of `Ndb_logevent_type`, `ndb_mgm_event_severity`, `ndb_mgm_logevent_handle_error`, and `ndb_mgm_event_category`, which are defined in `/storage/ndb/include/mgmapi/ndb_logevent.h`.

3.3.1 The ndb_mgm_node_type Type

Description. This is used to classify the different types of nodes in an NDB Cluster.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 3.1 Type ndb_mgm_node_type values and descriptions.

Value	Description
NDB_MGM_NODE_TYPE_UNKNOWN	Unknown
NDB_MGM_NODE_TYPE_API	API Node (SQL node)
NDB_MGM_NODE_TYPE_NDB	Data node
NDB_MGM_NODE_TYPE_MGM	Management node

3.3.2 The ndb_mgm_node_status Type

Description. This type describes a Cluster node's status.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 3.2 Type ndb_mgm_node_status values and descriptions.

Value	Description
NDB_MGM_NODE_STATUS_UNKNOWN	The node's status is not known
NDB_MGM_NODE_STATUS_NO_CONTACT	The node cannot be contacted
NDB_MGM_NODE_STATUS_NOT_STARTED	The node has not yet executed the startup protocol
NDB_MGM_NODE_STATUS_STARTING	The node is executing the startup protocol
NDB_MGM_NODE_STATUS_STARTED	The node is running
NDB_MGM_NODE_STATUS_SHUTTING_DOWN	The node is shutting down
NDB_MGM_NODE_STATUS_RESTARTING	The node is restarting
NDB_MGM_NODE_STATUS_SINGLEUSER	The node is running in single-user (maintenance) mode
NDB_MGM_NODE_STATUS_RESUME	The node is in resume mode
NDB_MGM_NODE_STATUS_CONNECTED	The node is connected

3.3.3 The ndb_mgm_error Type

Description. The values for this type are the error codes that may be generated by MGM API functions. These may be found in Section 3.5, “MGM API Errors”.

See also Section 3.2.2.1, “ndb_mgm_get_latest_error()”, for more information.

3.3.4 The Ndb_logevent_type Type

Description. These are the types of log events available in the MGM API, grouped by event category. (See Section 3.3.7, “The ndb_mgm_event_category Type”.)

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 3.3 Type Ndb_logevent_type values, descriptions, and event categories

Type	Description	Category
NDB_LE_Connected	The node has connected	NDB_MGM_EVENT_CATEGORY_CONNECTION
NDB_LE_Disconnected	The node was disconnected	NDB_MGM_EVENT_CATEGORY_CONNECTION
NDB_LE_CommunicationClosed	Communication with the node has been closed	NDB_MGM_EVENT_CATEGORY_CONNECTION
NDB_LE_CommunicationOpened	Communication with the node has been started	NDB_MGM_EVENT_CATEGORY_CONNECTION
NDB_LE_ConnectedApiVersion	The API version used by an API node; in the case of a MySQL server (SQL node), this is the same as displayed by SELECT VERSION()	NDB_MGM_EVENT_CATEGORY_CONNECTION
NDB_LE_GlobalCheckpointStarted	A global checkpoint has been started	NDB_MGM_EVENT_CATEGORY_CHECKPOINT
NDB_LE_GlobalCheckpointCompleted	A global checkpoint has been completed	NDB_MGM_EVENT_CATEGORY_CHECKPOINT
NDB_LE_LocalCheckpointStarted	The node has begun a local checkpoint	NDB_MGM_EVENT_CATEGORY_CHECKPOINT
NDB_LE_LocalCheckpointCompleted	The node has completed a local checkpoint	NDB_MGM_EVENT_CATEGORY_CHECKPOINT
NDB_LE_LCPStoppedInCalcKeepGci	The lcoal checkpoint was aborted, but the last global checkpoint was preserved	NDB_MGM_EVENT_CATEGORY_CHECKPOINT
NDB_LE_LCPFragmentCompleted	Copying of a table fragment was completed	NDB_MGM_EVENT_CATEGORY_CHECKPOINT
NDB_LE_NDBStartStarted	The node has begun to start	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_NDBStartCompleted	The node has completed the startup process	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_STTORRYRecieved	The node received an STTORRY signal, indicating that the reading of configuration data is underway; see Configuration Read Phase (STTOR Phase -1), and STTOR Phase 0, for more information	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_StartPhaseCompleted	A node start phase has been completed	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_CM_REGCONF	The node has received a CM_REGCONF signal; see STTOR Phase 1, for more information	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_CM_REGREF	The node has received a CM_REGREF signal; see STTOR Phase 1, for more information	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_FIND_NEIGHBOURS	The node has discovered its neighboring nodes in the cluster	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_NDBStopStarted	The node is beginning to shut down	NDB_MGM_EVENT_CATEGORY_STARTUP

Type	Description	Category
NDB_LE_NDBStopCompleted	Node shutdown completed	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_NDBStopForced	The node is being forced to shut down (usually indicates a severe problem in the cluster)	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_NDBStopAborted	The started to shut down, but was forced to continue running; this happens, for example, when a STOP command was issued in the management client for a node such that the cluster would no longer be able to keep all data available if the node were shut down	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_StartREDOLog	Redo logging has been started	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_StartLog	Logging has started	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_UNDORecordsExecuted	The node has read and executed all records from the redo log	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_StartReport	The node is issuing a start report	NDB_MGM_EVENT_CATEGORY_STARTUP
NDB_LE_NR_CopyDict	The node is copying the data dictionary	NDB_MGM_EVENT_CATEGORY_NODE_RESTART
NDB_LE_NR_CopyDistr	The node is copying data distribution information	NDB_MGM_EVENT_CATEGORY_NODE_RESTART
NDB_LE_NR_CopyFragsStarted	The node is copying table fragments	NDB_MGM_EVENT_CATEGORY_NODE_RESTART
NDB_LE_NR_CopyFragDone	The node has completed copying a table fragment	NDB_MGM_EVENT_CATEGORY_NODE_RESTART
NDB_LE_NR_CopyFragsCompleted	The node has completed copying all necessary table fragments	NDB_MGM_EVENT_CATEGORY_NODE_RESTART
NDB_LE_NodeFailCompleted	All (remaining) nodes has been notified of the failure of a data node	NDB_MGM_EVENT_CATEGORY_NODE_RESTART
NDB_LE_NODE_FAILREP	A data node has failed	NDB_MGM_EVENT_CATEGORY_NODE_RESTART
NDB_LE_ArbitState	This event is used to report on the current state of arbitration in the cluster	NDB_MGM_EVENT_CATEGORY_NODE_RESTART
NDB_LE_ArbitResult	This event is used to report on the outcome of node arbitration	NDB_MGM_EVENT_CATEGORY_NODE_RESTART
NDB_LE_GCP_TakeoverStarted	The node is attempting to become the master node (to assume responsibility for GCPs)	NDB_MGM_EVENT_CATEGORY_NODE_RESTART

Type	Description	Category
NDB_LE_GCP_TakeoverCompleted	The node has become the master (and assumed responsibility for GCPs)	NDB_MGM_EVENT_CATEGORY_NODE_RESTART
NDB_LE_LCP_TakeoverStarted	The node is attempting to become the master node (to assume responsibility for LCPs)	NDB_MGM_EVENT_CATEGORY_NODE_RESTART
NDB_LE_LCP_TakeoverCompleted	The node has become the master (and assumed responsibility for LCPs)	NDB_MGM_EVENT_CATEGORY_NODE_RESTART
NDB_LE_TransReportCounters	This indicates a report of transaction activity, which is given approximately once every 10 seconds	NDB_MGM_EVENT_CATEGORY_STATISTIC
NDB_LE_OperationReportCounters	Indicates a report on the number of operations performed by this node (also provided approximately once every 10 seconds)	NDB_MGM_EVENT_CATEGORY_STATISTIC
NDB_LE_TableCreated	A new table has been created	NDB_MGM_EVENT_CATEGORY_STATISTIC
NDB_LE_UndoLogBlocked	Undo logging is blocked because the log buffer is close to overflowing	NDB_MGM_EVENT_CATEGORY_STATISTIC
NDB_LE_JobStatistic	...	NDB_MGM_EVENT_CATEGORY_STATISTIC
NDB_LE_SendBytesStatistic	Indicates a report of the average number of bytes transmitted per send operation by this node	NDB_MGM_EVENT_CATEGORY_STATISTIC
NDB_LE_ReceiveBytesStatistic	Indicates a report of the average number of bytes received per send operation to this node	NDB_MGM_EVENT_CATEGORY_STATISTIC
NDB_LE_MemoryUsage	A DUMP 1000 command has been issued to this node, and it is reporting its memory usage in turn	NDB_MGM_EVENT_CATEGORY_STATISTIC
NDB_LE_TransporterError	A transporter error has occurred; see NDB Transporter Errors, for transporter error codes and messages	NDB_MGM_EVENT_CATEGORY_ERROR
NDB_LE_TransporterWarning	A potential problem is occurring in the transporter; see NDB Transporter Errors, for transporter error codes and messages	NDB_MGM_EVENT_CATEGORY_ERROR
NDB_LE_MissedHeartbeat	Indicates a data node has missed a hreatbeat expected from another data node	NDB_MGM_EVENT_CATEGORY_ERROR

Type	Description	Category
NDB_LE_DeadDueToHeartbeat	A data node has missed at least 3 heartbeats in succssion from another data node, and is reporting that it can no longer communicate with that data node	NDB_MGM_EVENT_CATEGORY_ERROR
NDB_LE_WarningEvent	Indicates a warning message	NDB_MGM_EVENT_CATEGORY_ERROR
NDB_LE_SentHeartbeat	A node heartbeat has been sent	NDB_MGM_EVENT_CATEGORY_INFO
NDB_LE_CreateLogBytes	...	NDB_MGM_EVENT_CATEGORY_INFO
NDB_LE_InfoEvent	Indicates an informational message	NDB_MGM_EVENT_CATEGORY_INFO
NDB_LE_SingleUser	The cluster has entered or exited single user mode	NDB_MGM_EVENT_CATEGORY_INFO
NDB_LE_EventBufferStatus	This type of event indicates potentially excessive usage of the event buffer	NDB_MGM_EVENT_CATEGORY_INFO
NDB_LE_EventBufferStatus2	Provides improved reporting of event buffer status; added in NDB 7.5.1	NDB_MGM_EVENT_CATEGORY_INFO
NDB_LE_BackupStarted	A backup has been started	NDB_MGM_EVENT_CATEGORY_BACKUP
NDB_LE_BackupFailedToStart	A backup has failed to start	NDB_MGM_EVENT_CATEGORY_BACKUP
NDB_LE_BackupCompleted	A backup has been completed successfully	NDB_MGM_EVENT_CATEGORY_BACKUP
NDB_LE_BackupAborted	A backup in progress was terminated by the user	NDB_MGM_EVENT_CATEGORY_BACKUP

3.3.5 The ndb_mgm_event_severity Type

Description. These are the log event severities used to filter the cluster log by `ndb_mgm_set_clusterlog_severity_filter()`, and to filter listening to events by `ndb_mgm_listen_event()`.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 3.4 Type ndb_mgm_event_severity values and descriptions

Value	Description
`NDB_MGM_ILLEGAL_EVENT_SEVERITY`	Invalid event severity specified
`NDB_MGM_EVENT_SEVERITY_ON`	Cluster logging is enabled
`NDB_MGM_EVENT_SEVERITY_DEBUG`	*Used for NDB Cluster development only*
`NDB_MGM_EVENT_SEVERITY_INFO`	Informational messages
`NDB_MGM_EVENT_SEVERITY_WARNING`	Conditions that are not errors as such, but that might require special handling
`NDB_MGM_EVENT_SEVERITY_ERROR`	Nonfatal error conditions that should be corrected
`NDB_MGM_EVENT_SEVERITY_CRITICAL`	Critical conditions such as device errors or out of memory errors
`NDB_MGM_EVENT_SEVERITY_ALERT`	Conditions that require immediate attention, such as corruption of the cluster
`NDB_MGM_EVENT_SEVERITY_ALL`	All severity levels

See Section 3.2.7.2, “ndb_mgm_set_clusterlog_severity_filter()”, and Section 3.2.1.1, “ndb_mgm_listen_event()”, for information on how this type is used by those functions.

3.3.6 The ndb_logevent_handle_error Type

Description. This type is used to describe log event errors.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 3.5 Type ndb_logevent_handle_error values and descriptions

Value	Description
`NDB_LEH_NO_ERROR`	No error
`NDB_LEH_READ_ERROR`	Read error
`NDB_LEH_MISSING_EVENT_SPECIFIER`	Invalid, incomplete, or missing log event specification
`NDB_LEH_UNKNOWN_EVENT_TYPE`	Unknown log event type
`NDB_LEH_UNKNOWN_EVENT_VARIABLE`	Unknown log event variable
`NDB_LEH_INTERNAL_ERROR`	Internal error
`NDB_LEH_CONNECTION_ERROR`	Connection error, or lost connection with management server

`NDB_LEH_CONNECTION_ERROR` was added in NDB 7.4.13 and NDB 7.5.4. (BUG #19474782)

3.3.7 The ndb_mgm_event_category Type

Description. These are the log event categories referenced in Section 3.3.4, "The Ndb_logevent_type Type". They are also used by the MGM API functions `ndb_mgm_set_clusterlog_loglevel()` and `ndb_mgm_listen_event()`.

Enumeration values. Possible values are shown, along with descriptions, in the following table:

Table 3.6 Type ndb_mgm_event_category values and descriptions

Value	Description
`NDB_MGM_ILLEGAL_EVENT_CATEGORY`	Invalid log event category
`NDB_MGM_EVENT_CATEGORY_STARTUP`	Log events occurring during startup
`NDB_MGM_EVENT_CATEGORY_SHUTDOWN`	Log events occurring during shutdown
`NDB_MGM_EVENT_CATEGORY_STATISTIC`	Statistics log events
`NDB_MGM_EVENT_CATEGORY_CHECKPOINT`	Log events related to checkpoints
`NDB_MGM_EVENT_CATEGORY_NODE_RESTART`	Log events occurring during node restart
`NDB_MGM_EVENT_CATEGORY_CONNECTION`	Log events relating to connections between cluster nodes
`NDB_MGM_EVENT_CATEGORY_BACKUP`	Log events relating to backups
`NDB_MGM_EVENT_CATEGORY_CONGESTION`	Log events relating to congestion
`NDB_MGM_EVENT_CATEGORY_INFO`	Uncategorised log events (severity level `INFO`)
`NDB_MGM_EVENT_CATEGORY_ERROR`	Uncategorised log events (severity level `WARNING`, `ERROR`, `CRITICAL`, or `ALERT`)

See Section 3.2.7.4, "ndb_mgm_set_clusterlog_loglevel()", and Section 3.2.1.1, "ndb_mgm_listen_event()", for more information.

3.4 MGM API Structures

This section covers the programming structures available in the MGM API.

3.4.1 The ndb_logevent Structure

Description. This structure models a Cluster log event, and is used for storing and retrieving log event information.

Definition. `ndb_logevent` has 8 members, the first 7 of which are shown in the following list:

- `void* handle`: An `NdbLogEventHandle`, set by `ndb_logevent_get_next()`. This handle is used only for purposes of comparison.
- `type`: Tells which type of event (`Ndb_logevent_type`) this is.
- `unsigned time`: The time at which the log event was registered with the management server.
- `category`: The log event category (`ndb_mgm_event_category`).
- `severity`: The log event severity (`ndb_mgm_event_severity`).
- `unsigned level`: The log event level. This is a value in the range of 0 to 15, inclusive.
- `unsigned source_nodeid`: The node ID of the node that reported this event.

The 8th member of this structure contains data specific to the log event, and is dependent on its type. It is defined as the union of a number of data structures, each corresponding to a log event type. Which structure to use is determined by the value of `type`, and is shown in the following table:

Table 3.7 Type Ndb_logevent_type values and structures used

`Ndb_logevent_type` Value	Structure
NDB_LE_Connected	Connected: `unsigned node`
NDB_LE_Disconnected	Disconnected: `unsigned node`
NDB_LE_CommunicationClosed	CommunicationClosed: `unsigned node`
NDB_LE_CommunicationOpened	CommunicationOpened: `unsigned node`

NDB_LE_ConnectedApiVersion	ConnectedApiVersion:
	`unsigned node`
	`unsigned version`

NDB_LE_GlobalCheckpointStarted	GlobalCheckpointStarted: `unsigned gci`
NDB_LE_GlobalCheckpointCompleted	GlobalCheckpointCompleted: `unsigned gci`

NDB_LE_LocalCheckpointStarted	LocalCheckpointStarted:
	`unsigned lci`
	`unsigned keep_gci`
	`unsigned restore_gci`

NDB_LE_LocalCheckpointCompleted	LocalCheckpointCompleted: `unsigned lci`
NDB_LE_LCPStoppedInCalcKeepGci	LCPStoppedInCalcKeepGci: `unsigned data`

NDB_LE_LCPFragmentCompleted	LCPFragmentCompleted:
	`unsigned node`
	`unsigned table_id`
	`unsigned fragment_id`

NDB_LE_UndoLogBlocked	UndoLogBlocked:
	`unsigned acc_count`
	`unsigned tup_count`

NDB_LE_NDBStartStarted	NDBStartStarted: `unsigned version`
NDB_LE_NDBStartCompleted	NDBStartCompleted: `unsigned version`
NDB_LE_STTORRYRecieved	STTORRYRecieved: `[NONE]`

NDB_LE_StartPhaseCompleted	StartPhaseCompleted:
	`unsigned phase`
	`unsigned starttype`

NDB_LE_CM_REGCONF	CM_REGCONF:

Ndb_logevent_type Value	**Structure**

	`unsigned own_id`
	`unsigned president_id`
	`unsigned dynamic_id`

NDB_LE_CM_REGREF	CM_REGREF:
	`unsigned own_id`
	`unsigned other_id`
	`unsigned cause`

NDB_LE_FIND_NEIGHBOURS	FIND_NEIGHBOURS:
	`unsigned own_id`
	`unsigned left_id`
	`unsigned right_id`
	`unsigned dynamic_id`

NDB_LE_NDBStopStarted	NDBStopStarted: `unsigned stoptype`

NDB_LE_NDBStopCompleted	NDBStopCompleted:
	`unsigned action`
	`unsigned signum`

NDB_LE_NDBStopForced	NDBStopForced:
	`unsigned action`
	`unsigned signum`
	`unsigned error`
	`unsigned sphase`
	`unsigned extra`

NDB_LE_NDBStopAborted	NDBStopAborted: `[NONE]`

NDB_LE_StartREDOLog	StartREDOLog:
	`unsigned node`
	`unsigned keep_gci`
	`unsigned completed_gci`
	`unsigned restorable_gci`

NDB_LE_StartLog	StartLog:
	`unsigned log_part`
	`unsigned start_mb`
	`unsigned stop_mb`
	`unsigned gci`

NDB_LE_UNDORecordsExecuted	UNDORecordsExecuted:
	`unsigned block`
	`unsigned data1`
	`unsigned data2`
	`unsigned data3`
	`unsigned data4`
	`unsigned data5`
	`unsigned data6`
	`unsigned data7`
	`unsigned data8`
	`unsigned data9`
	`unsigned data10`

NDB_LE_NR_CopyDict	NR_CopyDict: `[NONE]`
NDB_LE_NR_CopyDistr	NR_CopyDistr: `[NONE]`

`Ndb_logevent_type` Value	Structure
`NDB_LE_NR_CopyFragsStarted`	`NR_CopyFragsStarted`: `unsigned dest_node`

`NDB_LE_NR_CopyFragDone`	`NR_CopyFragDone`:
	`unsigned dest_node`
	`unsigned table_id`
	`unsigned fragment_id`

`NDB_LE_NR_CopyFragsCompleted`	`NR_CopyFragsCompleted`: `unsigned dest_node`

`NDB_LE_NodeFailCompleted`	`NodeFailCompleted`:
	`unsigned block`
	`unsigned failed_node`
	`unsigned completing_node`
	(For *`block`* and *`completing_node`*, `0` is interpreted as “all”.)

`NDB_LE_NODE_FAILREP`	`NODE_FAILREP`:
	`unsigned failed_node`
	`unsigned failure_state`

`NDB_LE_ArbitState`	`ArbitState`:
	`unsigned code`
	`unsigned arbit_node`
	`unsigned ticket_0`
	`unsigned ticket_1`

`NDB_LE_ArbitResult`	`ArbitResult`:
	`unsigned code`
	`unsigned arbit_node`
	`unsigned ticket_0`
	`unsigned ticket_1`

`NDB_LE_GCP_TakeoverStarted`	`GCP_TakeoverStarted`: *[NONE]*
`NDB_LE_GCP_TakeoverCompleted`	`GCP_TakeoverCompleted`: *[NONE]*
`NDB_LE_LCP_TakeoverStarted`	`LCP_TakeoverStarted`: *[NONE]*

`NDB_LE_TransReportCounters`	`TransReportCounters`:
	`unsigned trans_count`
	`unsigned commit_count`
	`unsigned read_count`
	`unsigned simple_read_count`
	`unsigned write_count`
	`unsigned attrinfo_count`
	`unsigned conc_op_count`
	`unsigned abort_count`
	`unsigned scan_count`
	`unsigned range_scan_count`

`NDB_LE_OperationReportCounters`	`OperationReportCounters`: `unsigned ops`
`NDB_LE_TableCreated`	`TableCreated`:

Ndb_logevent_type Value	**Structure**
	unsigned *table_id*
NDB_LE_JobStatistic	JobStatistic: unsigned *mean_loop_count*
NDB_LE_SendBytesStatistic	SendBytesStatistic: unsigned *to_node* unsigned *mean_sent_bytes*
NDB_LE_ReceiveBytesStatistic	ReceiveBytesStatistic: unsigned *from_node* unsigned *mean_received_bytes*
NDB_LE_MemoryUsage	MemoryUsage: int *gth* unsigned *page_size_kb* unsigned *pages_used* unsigned *pages_total* unsigned *block*
NDB_LE_TransporterError	TransporterError: unsigned *to_node* unsigned *code*
NDB_LE_TransporterWarning	TransporterWarning: unsigned *to_node* unsigned *code*
NDB_LE_MissedHeartbeat	MissedHeartbeat: unsigned *node* unsigned *count*
NDB_LE_DeadDueToHeartbeat	DeadDueToHeartbeat: unsigned *node*
NDB_LE_WarningEvent	WarningEvent: *[NOT YET IMPLEMENTED]*
NDB_LE_SentHeartbeat	SentHeartbeat: unsigned *node*
NDB_LE_CreateLogBytes	CreateLogBytes: unsigned *node*
NDB_LE_InfoEvent	InfoEvent: *[NOT YET IMPLEMENTED]*
NDB_LE_EventBufferStatus (NDB 7.5.0 and earlier)	EventBufferStatus:: unsigned *usage* unsigned *alloc* unsigned *max* unsigned *apply_gci_l* unsigned *apply_gci_h* unsigned *latest_gci_l* unsigned *latest_gci_h*
NDB_LE_EventBufferStatus2 (NDB 7.5.1 and later)	EventBufferStatus2: unsigned *usage* unsigned *alloc* unsigned *max*

Ndb_logevent_type Value	Structure

	`unsigned latest_consumed_epoch_l`
	`unsigned latest_consumed_epoch_h`
	`unsigned latest_buffered_epoch_l`
	`unsigned latest_buffered_epoch_h`
	`unsigned ndb_reference`
	`unsigned report_reason`
	
	report_reason is one of NO_REPORT, COMPLETELY_BUFFERING, PARTIALLY_DISCARDING, COMPLETELY_DISCARDING, PARTIALLY_BUFFERING, BUFFERED_EPOCHS_OVER_THRESHOLD, ENOUGH_FREE_EVENTBUFFER, or LOW_FREE_EVENTBUFFER; see Event Buffer Reporting in the Cluster Log, for descriptions of these values

NDB_LE_BackupStarted	BackupStarted:
	
	`unsigned starting_node`
	`unsigned backup_id`

NDB_LE_BackupFailedToStart	BackupFailedToStart:
	
	`unsigned starting_node`
	`unsigned error`

NDB_LE_BackupCompleted	BackupCompleted:
	
	`unsigned starting_node`
	`unsigned backup_id`
	`unsigned start_gci`
	`unsigned stop_gci`
	`unsigned n_records`
	`unsigned n_log_records`
	`unsigned n_bytes`
	`unsigned n_log_bytes`

NDB_LE_BackupAborted	BackupAborted:
	
	`unsigned starting_node`
	`unsigned backup_id`
	`unsigned error`

NDB_LE_SingleUser	SingleUser:
	
	`unsigned type`
	`unsigned node_id`

NDB_LE_StartReport	StartReport:
	
	`unsigned report_type`
	`unsigned remaining_time`
	`unsigned bitmask_size`
	`unsigned bitmask_data[1]`

3.4.2 The ndb_mgm_node_state Structure

Description. Provides information on the status of a Cluster node.

Definition. This structure contains the following members:

- `int` *node_id*: The cluster node's node ID.
- `enum ndb_mgm_node_type` *node_type*: The node type.

  See Section 3.3.1, “The ndb_mgm_node_type Type”, for permitted values.

- `enum ndb_mgm_node_status` *`node_status`*: The node's status.

  See Section 3.3.2, “The ndb_mgm_node_status Type”, for permitted values.

- `int` *`start_phase`*: The start phase.

  This is valid only if the *`node_type`* is `NDB_MGM_NODE_TYPE_NDB` and the *`node_status`* is `NDB_MGM_NODE_STATUS_STARTING`.

- `int` *`dynamic_id`*: The ID for heartbeats and master takeover.

  Valid only for data (`ndbd`) nodes.

- `int` *`node_group`*: The node group to which the node belongs.

  Valid only for data (`ndbd`) nodes.

- `int` *`version`*: Internal version number.

- `int` *`connect_count`*: The number of times this node has connected to or disconnected from the management server.

- `char` *`connect_address[]`*: The IP address of this node as seen by the other nodes in the cluster.

- `int` *`mysql_version`*: The MySQL version number, expressed as an integer (for example: `80021`). Applies only to SQL nodes.

- `int` *`is_single_user`*: The node ID of the API or SQL node having exclusive access when the cluster is in single user mode. Does not otherwise apply. Added in NDB 8.0.17.

3.4.3 The ndb_mgm_cluster_state Structure

Description. Provides information on the status of all Cluster nodes. This structure is returned by `ndb_mgm_get_status()`.

Definition. This structure has the following two members:

- `int` *`no_of_nodes`*: The number of elements in the *`node_states`* array.

- `struct ndb_mgm_node_state` *`node_states[]`*: An array containing the states of the nodes.

  Each element of this array is an `ndb_mgm_node_state` structure.

See Section 3.2.5.1, “ndb_mgm_get_status()”.

3.4.4 The ndb_mgm_reply Structure

Description. Contains response information, consisting of a response code and a corresponding message, from the management server.

Definition. This structure contains two members, as shown here:

- `int` *`return_code`*: For a successful operation, this value is `0`; otherwise, it contains an error code.

  For error codes, see Section 3.3.3, “The ndb_mgm_error Type”.

- `char` *`message[256]`*: contains the text of the response or error message.

See Section 3.2.2.1, “ndb_mgm_get_latest_error()”, and Section 3.2.2.2, “ndb_mgm_get_latest_error_msg()”.

3.5 MGM API Errors

The following sections list the values of `MGM` errors by type. There are six types of `MGM` errors:

1. request errors
2. node ID allocation errors
3. service errors
4. backup errors
5. single user mode errors
6. general usage errors

There is only one general usage error.

3.5.1 Request Errors

These are errors generated by failures to connect to a management server.

Table 3.8 Request errors generated by management server connection failures.

Value	Description
NDB_MGM_ILLEGAL_CONNECT_STRING	Invalid connection string
NDB_MGM_ILLEGAL_SERVER_HANDLE	Invalid management server handle
NDB_MGM_ILLEGAL_SERVER_REPLY	Invalid response from management server
NDB_MGM_ILLEGAL_NUMBER_OF_NODES	Invalid number of nodes
NDB_MGM_ILLEGAL_NODE_STATUS	Invalid node status
NDB_MGM_OUT_OF_MEMORY	Memory allocation error
NDB_MGM_SERVER_NOT_CONNECTED	Management server not connected
NDB_MGM_COULD_NOT_CONNECT_TO_SOCKET	Not able to connect to socket

3.5.2 Node ID Allocation Errors

These errors result from a failure to assign a node ID to a cluster node.

Table 3.9 Node ID allocation errors resulting from failure to assign a node ID

Value	Description
NDB_MGM_ALLOCID_ERROR	Generic error; may be possible to retry and recover
NDB_MGM_ALLOCID_CONFIG_MISMATCH	Non-recoverable generic error

3.5.3 Service Errors

These errors result from the failure of a node or cluster to start, shut down, or restart.

Table 3.10 Service errors resulting from failure of a node or cluster to start, shut down, or restart

Value	Description
NDB_MGM_START_FAILED	Startup failure
NDB_MGM_STOP_FAILED	Shutdown failure
NDB_MGM_RESTART_FAILED	Restart failure

3.5.4 Backup Errors

These are errors which result from problems with initiating or aborting backups.

Table 3.11 Backup errors resulting from problems initiating or aborting backups.

Value	Description
NDB_MGM_COULD_NOT_START_BACKUP	Unable to initiate backup
NDB_MGM_COULD_NOT_ABORT_BACKUP	Unable to abort backup

3.5.5 Single User Mode Errors

These errors result from failures to enter or exit single user mode.

Table 3.12 Single user mode errors resulting from failure to enter or exit single user mode.

Value	Description
NDB_MGM_COULD_NOT_ENTER_SINGLE_USER_MODE	Unable to enter single-user mode
NDB_MGM_COULD_NOT_EXIT_SINGLE_USER_MODE	Unable to exit single-user mode

3.5.6 General Usage Errors

This is a general error type for errors which are otherwise not classifiable.

Table 3.13 General usage errors, otherwise not classified.

Value	Description
NDB_MGM_USAGE_ERROR	General usage error

3.6 MGM API Examples

This section contains MGM API coding examples.

3.6.1 Basic MGM API Event Logging Example

This example shows the basics of handling event logging using the MGM API.

The source code for this program may be found in the NDB Cluster source tree, in the file storage/ndb/ndbapi-examples/mgmapi_logevent/main.cpp.

```
#include <mysql.h>
#include <ndbapi/NdbApi.hpp>
#include <mgmapi.h>
#include <stdio.h>
#include <stdlib.h>

/*
 * export LD_LIBRARY_PATH=../../../../libmysql_r/.libs:../../src/.libs
 */

#define MGMERROR(h) \
{ \
  fprintf(stderr, "code: %d msg: %s\n", \
          ndb_mgm_get_latest_error(h), \
          ndb_mgm_get_latest_error_msg(h)); \
  exit(-1); \
}

#define LOGEVENTERROR(h) \
{ \
  fprintf(stderr, "code: %d msg: %s\n", \
          ndb_logevent_get_latest_error(h), \
          ndb_logevent_get_latest_error_msg(h)); \
  exit(-1); \
}

#define make_uint64(a,b) (((Uint64)(a)) + (((Uint64)(b)) << 32))

int main(int argc, char** argv)
```

```
{
  NdbMgmHandle h;
  NdbLogEventHandle le;
  int filter[] = { 15, NDB_MGM_EVENT_CATEGORY_BACKUP,
     15, NDB_MGM_EVENT_CATEGORY_CONNECTION,
     15, NDB_MGM_EVENT_CATEGORY_NODE_RESTART,
     15, NDB_MGM_EVENT_CATEGORY_STARTUP,
     15, NDB_MGM_EVENT_CATEGORY_ERROR,
     0 };
  struct ndb_logevent event;

  if (argc < 2)
  {
    printf("Arguments are <connect_string cluster> [<iterations>].\n");
    exit(-1);
  }
  const char *connectstring = argv[1];
  int iterations = -1;
  if (argc > 2)
    iterations = atoi(argv[2]);
  ndb_init();

  h= ndb_mgm_create_handle();
  if ( h == 0)
  {
    printf("Unable to create handle\n");
    exit(-1);
  }
  if (ndb_mgm_set_connectstring(h, connectstring) == -1)
  {
    printf("Unable to set connection string\n");
    exit(-1);
  }
  if (ndb_mgm_connect(h,0,0,0)) MGMERROR(h);

  le= ndb_mgm_create_logevent_handle(h, filter);
  if ( le == 0 )  MGMERROR(h);

  while (iterations-- != 0)
  {
    int timeout= 1000;
    int r= ndb_logevent_get_next(le,&event,timeout);
    if (r == 0)
      printf("No event within %d milliseconds\n", timeout);
    else if (r < 0)
      LOGEVENTERROR(le)
    else
    {
      switch (event.type) {
      case NDB_LE_BackupStarted:
 printf("Node %d: BackupStarted\n", event.source_nodeid);
 printf("  Starting node ID: %d\n", event.BackupStarted.starting_node);
 printf("  Backup ID: %d\n", event.BackupStarted.backup_id);
 break;
      case NDB_LE_BackupStatus:
 printf("Node %d: BackupStatus\n", event.source_nodeid);
 printf("  Starting node ID: %d\n", event.BackupStarted.starting_node);
 printf("  Backup ID: %d\n", event.BackupStarted.backup_id);
 printf("  Data written: %llu bytes (%llu records)\n",
               make_uint64(event.BackupStatus.n_bytes_lo,
                           event.BackupStatus.n_bytes_hi),
               make_uint64(event.BackupStatus.n_records_lo,
                           event.BackupStatus.n_records_hi));
 printf("  Log written: %llu bytes (%llu records)\n",
               make_uint64(event.BackupStatus.n_log_bytes_lo,
                           event.BackupStatus.n_log_bytes_hi),
               make_uint64(event.BackupStatus.n_log_records_lo,
                           event.BackupStatus.n_log_records_hi));
 break;
      case NDB_LE_BackupCompleted:
 printf("Node %d: BackupCompleted\n", event.source_nodeid);
 printf("  Backup ID: %d\n", event.BackupStarted.backup_id);
```

```
 printf("  Data written: %llu bytes (%llu records)\n",
               make_uint64(event.BackupCompleted.n_bytes,
                           event.BackupCompleted.n_bytes_hi),
               make_uint64(event.BackupCompleted.n_records,
                           event.BackupCompleted.n_records_hi));
 printf("  Log written: %llu bytes (%llu records)\n",
               make_uint64(event.BackupCompleted.n_log_bytes,
                           event.BackupCompleted.n_log_bytes_hi),
               make_uint64(event.BackupCompleted.n_log_records,
                           event.BackupCompleted.n_log_records_hi));
 break;
      case NDB_LE_BackupAborted:
 printf("Node %d: BackupAborted\n", event.source_nodeid);
 break;
      case NDB_LE_BackupFailedToStart:
 printf("Node %d: BackupFailedToStart\n", event.source_nodeid);
 break;

      case NDB_LE_NodeFailCompleted:
 printf("Node %d: NodeFailCompleted\n", event.source_nodeid);
 break;
      case NDB_LE_ArbitResult:
 printf("Node %d: ArbitResult\n", event.source_nodeid);
 printf("  code %d, arbit_node %d\n",
        event.ArbitResult.code & 0xffff,
        event.ArbitResult.arbit_node);
 break;
      case NDB_LE_DeadDueToHeartbeat:
 printf("Node %d: DeadDueToHeartbeat\n", event.source_nodeid);
 printf("  node %d\n", event.DeadDueToHeartbeat.node);
 break;

      case NDB_LE_Connected:
 printf("Node %d: Connected\n", event.source_nodeid);
 printf("  node %d\n", event.Connected.node);
 break;
      case NDB_LE_Disconnected:
 printf("Node %d: Disconnected\n", event.source_nodeid);
 printf("  node %d\n", event.Disconnected.node);
 break;
      case NDB_LE_NDBStartCompleted:
 printf("Node %d: StartCompleted\n", event.source_nodeid);
 printf("  version %d.%d.%d\n",
        event.NDBStartCompleted.version >> 16 & 0xff,
        event.NDBStartCompleted.version >> 8 & 0xff,
        event.NDBStartCompleted.version >> 0 & 0xff);
 break;
      case NDB_LE_ArbitState:
 printf("Node %d: ArbitState\n", event.source_nodeid);
 printf("  code %d, arbit_node %d\n",
        event.ArbitState.code & 0xffff,
        event.ArbitResult.arbit_node);
 break;

      default:
 break;
      }
    }
  }

  ndb_mgm_destroy_logevent_handle(&le);
  ndb_mgm_destroy_handle(&h);
  ndb_end(0);
  return 0;
}
```

3.6.2 MGM API Event Handling with Multiple Clusters

This example shown in this section illustrates the handling of log events using the MGM API on multiple clusters in a single application.

The source code for this program may be found in the NDB Cluster source tree, in the file `storage/ndb/ndbapi-examples/mgmapi_logevent2/main.cpp`.

Note

This file was previously named `mgmapi_logevent2.cpp`.

```
#include <mysql.h>
#include <ndbapi/NdbApi.hpp>
#include <mgmapi.h>
#include <stdio.h>
#include <stdlib.h>

/*
 * export LD_LIBRARY_PATH=../../../libmysql_r/.libs:../../../ndb/src/.libs
 */

#define MGMERROR(h) \
{ \
  fprintf(stderr, "code: %d msg: %s\n", \
          ndb_mgm_get_latest_error(h), \
          ndb_mgm_get_latest_error_msg(h)); \
  exit(-1); \
}

#define LOGEVENTERROR(h) \
{ \
  fprintf(stderr, "code: %d msg: %s\n", \
          ndb_logevent_get_latest_error(h), \
          ndb_logevent_get_latest_error_msg(h)); \
  exit(-1); \
}

int main(int argc, char** argv)
{
  NdbMgmHandle h1,h2;
  NdbLogEventHandle le1,le2;
  int filter[] = { 15, NDB_MGM_EVENT_CATEGORY_BACKUP,
     15, NDB_MGM_EVENT_CATEGORY_CONNECTION,
     15, NDB_MGM_EVENT_CATEGORY_NODE_RESTART,
     15, NDB_MGM_EVENT_CATEGORY_STARTUP,
     15, NDB_MGM_EVENT_CATEGORY_ERROR,
     0 };
  struct ndb_logevent event1, event2;

  if (argc < 3)
  {
    printf("Arguments are <connect_string cluster 1>",
           "<connect_string cluster 2> [<iterations>].\n");
    exit(-1);
  }
  const char *connectstring1 = argv[1];
  const char *connectstring2 = argv[2];
  int iterations = -1;
  if (argc > 3)
    iterations = atoi(argv[3]);
  ndb_init();

  h1= ndb_mgm_create_handle();
  h2= ndb_mgm_create_handle();
  if ( h1 == 0 || h2 == 0 )
  {
    printf("Unable to create handle\n");
    exit(-1);
  }
  if (ndb_mgm_set_connectstring(h1, connectstring1) == -1 ||
      ndb_mgm_set_connectstring(h2, connectstring1))
  {
    printf("Unable to set connection string\n");
    exit(-1);
  }
```

```
 if (ndb_mgm_connect(h1,0,0,0)) MGMERROR(h1);
 if (ndb_mgm_connect(h2,0,0,0)) MGMERROR(h2);

 if ((le1= ndb_mgm_create_logevent_handle(h1, filter)) == 0) MGMERROR(h1);
 if ((le2= ndb_mgm_create_logevent_handle(h1, filter)) == 0) MGMERROR(h2);

 while (iterations-- != 0)
 {
   int timeout= 1000;
   int r1= ndb_logevent_get_next(le1,&event1,timeout);
   if (r1 == 0)
     printf("No event within %d milliseconds\n", timeout);
   else if (r1 < 0)
     LOGEVENTERROR(le1)
   else
   {
     switch (event1.type) {
     case NDB_LE_BackupStarted:
printf("Node %d: BackupStarted\n", event1.source_nodeid);
printf("  Starting node ID: %d\n", event1.BackupStarted.starting_node);
printf("  Backup ID: %d\n", event1.BackupStarted.backup_id);
break;
     case NDB_LE_BackupCompleted:
printf("Node %d: BackupCompleted\n", event1.source_nodeid);
printf("  Backup ID: %d\n", event1.BackupStarted.backup_id);
break;
     case NDB_LE_BackupAborted:
printf("Node %d: BackupAborted\n", event1.source_nodeid);
break;
     case NDB_LE_BackupFailedToStart:
printf("Node %d: BackupFailedToStart\n", event1.source_nodeid);
break;

     case NDB_LE_NodeFailCompleted:
printf("Node %d: NodeFailCompleted\n", event1.source_nodeid);
break;
     case NDB_LE_ArbitResult:
printf("Node %d: ArbitResult\n", event1.source_nodeid);
printf("  code %d, arbit_node %d\n",
       event1.ArbitResult.code & 0xffff,
       event1.ArbitResult.arbit_node);
break;
     case NDB_LE_DeadDueToHeartbeat:
printf("Node %d: DeadDueToHeartbeat\n", event1.source_nodeid);
printf("  node %d\n", event1.DeadDueToHeartbeat.node);
break;

     case NDB_LE_Connected:
printf("Node %d: Connected\n", event1.source_nodeid);
printf("  node %d\n", event1.Connected.node);
break;
     case NDB_LE_Disconnected:
printf("Node %d: Disconnected\n", event1.source_nodeid);
printf("  node %d\n", event1.Disconnected.node);
break;
     case NDB_LE_NDBStartCompleted:
printf("Node %d: StartCompleted\n", event1.source_nodeid);
printf("  version %d.%d.%d\n",
       event1.NDBStartCompleted.version >> 16 & 0xff,
       event1.NDBStartCompleted.version >> 8 & 0xff,
       event1.NDBStartCompleted.version >> 0 & 0xff);
break;
     case NDB_LE_ArbitState:
printf("Node %d: ArbitState\n", event1.source_nodeid);
printf("  code %d, arbit_node %d\n",
       event1.ArbitState.code & 0xffff,
       event1.ArbitResult.arbit_node);
break;

     default:
break;
     }
```

```
    }

    int r2= ndb_logevent_get_next(le1,&event2,timeout);
    if (r2 == 0)
      printf("No event within %d milliseconds\n", timeout);
    else if (r2 < 0)
      LOGEVENTERROR(le2)
    else
    {
      switch (event2.type) {
      case NDB_LE_BackupStarted:
printf("Node %d: BackupStarted\n", event2.source_nodeid);
printf("  Starting node ID: %d\n", event2.BackupStarted.starting_node);
printf("  Backup ID: %d\n", event2.BackupStarted.backup_id);
break;
      case NDB_LE_BackupCompleted:
printf("Node %d: BackupCompleted\n", event2.source_nodeid);
printf("  Backup ID: %d\n", event2.BackupStarted.backup_id);
break;
      case NDB_LE_BackupAborted:
printf("Node %d: BackupAborted\n", event2.source_nodeid);
break;
      case NDB_LE_BackupFailedToStart:
printf("Node %d: BackupFailedToStart\n", event2.source_nodeid);
break;

      case NDB_LE_NodeFailCompleted:
printf("Node %d: NodeFailCompleted\n", event2.source_nodeid);
break;
      case NDB_LE_ArbitResult:
printf("Node %d: ArbitResult\n", event2.source_nodeid);
printf("  code %d, arbit_node %d\n",
       event2.ArbitResult.code & 0xffff,
       event2.ArbitResult.arbit_node);
break;
      case NDB_LE_DeadDueToHeartbeat:
printf("Node %d: DeadDueToHeartbeat\n", event2.source_nodeid);
printf("  node %d\n", event2.DeadDueToHeartbeat.node);
break;

      case NDB_LE_Connected:
printf("Node %d: Connected\n", event2.source_nodeid);
printf("  node %d\n", event2.Connected.node);
break;
      case NDB_LE_Disconnected:
printf("Node %d: Disconnected\n", event2.source_nodeid);
printf("  node %d\n", event2.Disconnected.node);
break;
      case NDB_LE_NDBStartCompleted:
printf("Node %d: StartCompleted\n", event2.source_nodeid);
printf("  version %d.%d.%d\n",
       event2.NDBStartCompleted.version >> 16 & 0xff,
       event2.NDBStartCompleted.version >> 8 & 0xff,
       event2.NDBStartCompleted.version >> 0 & 0xff);
break;
      case NDB_LE_ArbitState:
printf("Node %d: ArbitState\n", event2.source_nodeid);
printf("  code %d, arbit_node %d\n",
       event2.ArbitState.code & 0xffff,
       event2.ArbitResult.arbit_node);
break;

      default:
break;
      }
    }
  }

  ndb_mgm_destroy_logevent_handle(&le1);
  ndb_mgm_destroy_logevent_handle(&le2);
  ndb_mgm_destroy_handle(&h1);
  ndb_mgm_destroy_handle(&h2);
```

```
  ndb_end(0);
  return 0;
}
```

Chapter 4 MySQL NDB Cluster Connector for Java

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This chapter discusses using NDB Cluster with MySQL NDB Cluster Connector for Java, also known as ClusterJ.

ClusterJ is a high level database API that is similar in style and concept to object-relational mapping persistence frameworks such as Hibernate and JPA. Because ClusterJ does not use the MySQL Server to access data in NDB Cluster, it can perform some operations much more quickly than can be done using JDBC. ClusterJ supports primary key and unique key operations and single-table queries; it does not support multi-table operations, including joins.

4.1 MySQL NDB Cluster Connector for Java: Overview

This section provides a conceptual and architectural overview of the APIs available using the MySQL NDB Cluster Connector for Java.

4.1.1 MySQL NDB Cluster Connector for Java Architecture

MySQL NDB Cluster Connector for Java, also known as ClusterJ, is a Java API for writing applications against NDB Cluster. It is one among different access paths and styles of access to NDB Cluster data. Section 4.1.2, “Java and NDB Cluster”, describes each of those APIs in more detail.

MySQL NDB Cluster Connector for Java is included with all NDB Cluster source and binary releases. Building MySQL NDB Cluster Connector for Java from source can be done as part of building NDB Cluster; however, it can also be built with Maven.

4.1.2 Java and NDB Cluster

A NDB Cluster is defined as one or more MySQL Servers providing access to an `NDBCLUSTER` storage engine—that is, to a set of NDB Cluster data nodes (`ndbd` processes). There are three main access paths from Java to `NDBCLUSTER`, listed here:

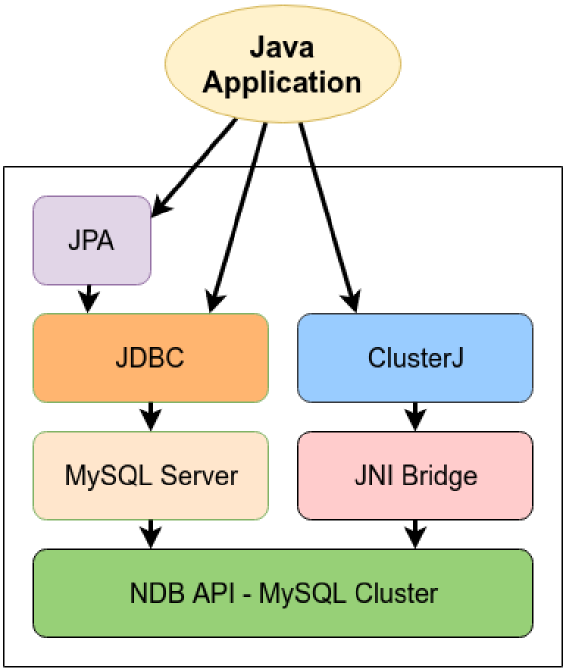
- **JDBC and mysqld.** JDBC works by sending SQL statements to the MySQL Server and returning result sets. When using JDBC, you must write the SQL, manage the connection, and copy any data from the result set that you want to use in your program as objects. The JDBC implementation most often used with the MySQL Server is MySQL Connector/J.

- **Java Persistence API (JPA) and JDBC.** JPA uses JDBC to connect to the MySQL Server. Unlike JDBC, JPA provides an object view of the data in the database.

- **ClusterJ.** ClusterJ uses a JNI bridge to the NDB API for direct access to `NDBCLUSTER`. It employs a style of data access that is based on a domain object model, similar in many ways to that employed by JPA. ClusterJ does not depend on the MySQL Server for data access.

These paths are shown in the following API stack diagram:

Figure 4.1 Java Access Paths To NDB



JDBC and mysqld. Connector/J provides standard access through the MySQL JDBC driver. Using Connector/J, JDBC applications can be written to work with a MySQL server acting as an NDB Cluster SQL node in much the same way that other Connector/J applications work with any other MySQL Server instance.

For more information, see Section 4.2.3, “Using Connector/J with NDB Cluster”.

ClusterJ. ClusterJ is a native Java Connector for `NDBCLUSTER` (or `NDB`), the storage engine for NDB Cluster, in the style of Hibernate, JPA, and JDO. Like other persistence frameworks, ClusterJ uses the Data Mapper pattern, in which data is represented as domain objects, separate from business logic, mapping Java classes to database tables stored in the `NDBCLUSTER` storage engine.

> **Note**
>
> The `NDBCLUSTER` storage engine is often referred to (in MySQL documentation and elsewhere) simply as `NDB`. The terms `NDB` and `NDBCLUSTER` are synonymous, and you can use either `ENGINE=NDB` or `ENGINE=NDBCLUSTER` in a `CREATE TABLE` statement to create a clustered table.

ClusterJ does not need to connect to a `mysqld` process, having direct access to `NDBCLUSTER` using a JNI bridge that is included in the dynamic library `libnbdclient`. However, unlike JDBC, ClusterJ does not support table creation and other data definition operations; these must be performed by some other means, such as JDBC or the `mysql` client. Also, ClusterJ is limited to queries on single tables, and does not support relations or inheritance; you should use another kind of access paths if you need support for those features in your applications.

4.1.3 The ClusterJ API and Data Object Model

This section discusses the ClusterJ API and the object model used to represent the data handled by the application.

Application Programming Interface. The ClusterJ API depends on 4 main interfaces: `Session`, `SessionFactory`, `Transaction`, and `QueryBuilder`.

Session interface. All access to NDB Cluster data is done in the context of a session. The `Session` interface represents a user's or application's individual connection to an NDB Cluster. It contains methods for the following operations:

- Finding persistent instances by primary key
- Creating, updating, and deleting persistent instances
- Getting a query builder (see com.mysql.clusterj.query.QueryBuilder)
- Getting the current transaction (see com.mysql.clusterj.Transaction).

SessionFactory interface. Sessions are obtained from a `SessionFactory`, of which there is typically a single instance for each NDB Cluster that you want to access from the Java VM. `SessionFactory` stores configuration information about the cluster, such as the hostname and port number of the NDB Cluster management server. It also stores parameters regarding how to connect to the cluster, including connection delays and timeouts. For more information about SessionFactory and its use in a ClusterJ application, see Getting the SessionFactory and getting a Session.

Transaction interface. Transactions are not managed by the `Session` interface; like other modern application frameworks, ClusterJ separates transaction management from other persistence methods. Transaction demarcation might be done automatically by a container or in a web server servlet filter. Removing transaction completion methods from `Session` facilitates this separation of concerns.

The `Transaction` interface supports the standard begin, commit, and rollback behaviors required by a transactional database. In addition, it enables the user to mark a transaction as being rollback-only, which makes it possible for a component that is not responsible for completing a transaction to indicate that—due to an application or database error—the transaction must not be permitted to complete normally.

QueryBuilder interface. The `QueryBuilder` interface makes it possible to construct criteria queries dynamically, using domain object model properties as query modeling elements. Comparisons between parameters and database column values can be specified, including equal, greater and less than, between, and in operations. These comparisons can be combined using methods corresponding to the Boolean operators AND, OR, and NOT. Comparison of values to `NULL` is also supported.

Data model. ClusterJ provides access to data in NDB Cluster using domain objects, similar in many ways to the way that JPA models data.

In ClusterJ, the domain object mapping has the following characteristics:

- All tables map to persistent interfaces. For every `NDB` table in the cluster, ClusterJ uses one or more interfaces. In many cases, a single interface is used; but for cases where different columns are needed by different parts of the application, multiple interfaces can be mapped to the same table.

  However, the classes themselves are not persistent.

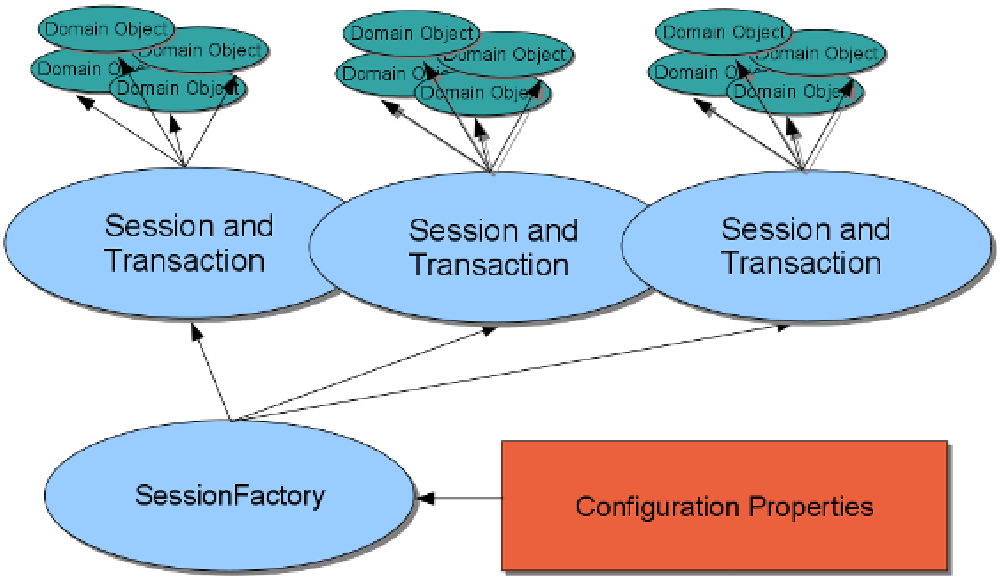
- Users map a subset of columns to persistent properties in interfaces. Thus, all properties map to columns; however, not all columns necessarily map to properties.

  All ClusterJ property names default to column names. The interface provides getter and setter methods for each property, with predictable corresponding method names.

- Annotations on interfaces define mappings.

The user view of the application environment and domain objects is illustrated in the following diagram, which shows the logical relationships among the modeling elements of the ClusterJ interfaces:

Figure 4.2 ClusterJ User View Of Application And Environment



The `SessionFactory` is configured by a properties object that might have been loaded from a file or constructed dynamically by the application using some other means (see Section 4.2.2.1, "Executing ClusterJ Applications and Sessions").

The application obtains `Session` instances from the `SessionFactory`, with at most one thread working with a `Session` at a time. A thread can manage multiple `Session` instances if there is some application requirement for multiple connections to the database.

Each session has its own collection of domain objects, each of which represents the data from one row in the database. The domain objects can represent data in any of the following states:

- New; not yet stored in the database
- Retrieved from the database; available to the application
- Updated; to be stored back in the database
- To be deleted from the database

4.2 Using MySQL NDB Cluster Connector for Java

This section provides basic information about building and running Java applications using MySQL NDB Cluster Connector for Java (ClusterJ).

4.2.1 Getting, Installing, and Setting Up MySQL NDB Cluster Connector for Java

This section discusses how to obtain ClusterJ sources and binaries, and how to compile, install, and get started with ClusterJ.

Obtaining and Installing MySQL NDB Cluster Connector for Java. You can obtain the most recent NDB Cluster release, which includes ClusterJ, from downloads.mysql.com. The installation instructions given in NDB Cluster Installation also install ClusterJ.

Building and installing MySQL NDB Cluster Connector for Java from source. You can build and install ClusterJ as part of building and installing NDB Cluster, which always requires you to configure the build using the CMake option `WITH_NDBCLUSTER_STORAGE_ENGINE` (or its alias `WITH_NDBCLUSTER`).

A typical CMake command for configuring a build for NDB Cluster that supports ClusterJ might look like this:

```
cmake .. -DWITH_BOOST=/usr/local/boost_1_59_0 -DWITH_NDBCLUSTER=ON
```

The `WITH_NDB_JAVA` option is enabled by default, which means ClusterJ is be built together with NDB Cluster by the above command. However, if CMake cannot find the location of Java on your system, the configuration process is going to fail; use the `WITH_CLASSPATH` option to provide the Java classpath if needed. Also, because ClusterJ uses the `ucs2` character set for internal storage and ClusterJ cannot be built without it, if you ever use the `WITH_EXTRA_CHARSETS` CMake option and change its value from the default setting of `all`, you should make sure that `ucs2` is specified in the character set list passed to the option. For information about other CMake options that can be used, see option_cmake_with_ndbcluster.

After configuring the build with CMake, run `make` and `make install` as you normally would to compile and install the NDB Cluster software.

MySQL NDB Cluster Connector for Java jar files. Following the installation, these ClusterJ jar files can be found in the folder `share/java` under the MySQL installation directory (which is `/usr/local/mysql` by default for Linux platforms):

- `clusterj-api-`*`version`*`.jar`: This is the compile-time jar file, required for compiling ClusterJ application code.
- `clusterj-`*`version`*`.jar`: This is the runtime library required for executing ClusterJ applications.
- `clusterj-test-`*`version`*`.jar`: This is the ClusterJ test suite, required for testing your ClusterJ installation.

Building ClusterJ with Maven

The source files for ClusterJ are configured as Maven projects, allowing easy compilation and installation using Maven. Assuming you have obtained the NDB Cluster source and already compiled and installed NDB Cluster and ClusterJ following the instructions given above, these are the steps to take:

1. Add the file path for the folder that contains the NDB client library (`libndbclient.so`) as a property named `ndbclient.lib` to your local Maven `settings.xml` file (found in the local Maven repository, which is usually `/home/`*`username`*`/.m2` for Linux platforms). The client library is to be found under the `lib` folder in the NDB Cluster's installation folder. If `settings.xml` does not exist in your local Maven repository, create one. This is how a simple `settings.xml` file containing the `ndbclient.lib` property looks like:

   ```
   <settings xmlns="http://maven.apache.org/SETTINGS/1.0.0"
     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
     xsi:schemaLocation="http://maven.apache.org/SETTINGS/1.0.0
                         http://maven.apache.org/xsd/settings-1.0.0.xsd">
     <profiles>
       <profile>
         <id>jni-library</id>
         <activation>
           <activeByDefault>true</activeByDefault>
         </activation>
         <properties>
           <ndbclient.lib>/NDB_Cluster_installation_directory/lib/</ndbclient.lib>
         </properties>
       </profile>
     </profiles>
   ```

```
</settings>
```

2. Go to the build directory you created when compiling NDB Cluster (which is `bld` in the sample steps in Build the Distribution), and then to the `storage/ndb/clusterj` folder under it. Run the `mvn_install_ndbjtie.sh` script in the folder:

   ```
   ./mvn_install_ndbjtie.sh
   ```

   It installs `ndbjtie.jar`, which provides the JNI layer for ClusterJ and is required for building CluterJ.

3. Install ClusterJ with Maven by running `mvn install` in the `storage/ndb/clusterj` directory:

   ```
   mvn install
   ```

   This causes ClusterJ to be built, with the resulting `.jar` files installed in the local Maven repository.

   Note

   You can skip the tests that takes place towards the end of the installation process by adding the option `skipTests` to the command:

   ```
   mvn install -DskipTests
   ```

   This prevents your installation from failing because you have not yet set up the testing environment.

Building ClusterJ with Maven in IDEs

Because the source files for ClusterJ are configured as Maven projects, you can easily import them into your favorite Maven-enabled IDEs, customize them, and rebuild them as needed by following these steps:

1. Make sure that your IDE's support for Maven is enabled. You might need to install a Maven plugin for the purpose.

2. Follow step 1 and 2 in Building ClusterJ with Maven, which make the ClusterJ source ready to be used with Maven.

3. Import ClusterJ as a Maven project. This is how to do it in some popular IDEs :

   In NetBeans:

   - In the main menu, choose **File** > **Open Project**. The **Open Project** dialogue box appears
   - In the **Open Project** dialogue box, browse to the `storage/ndb` folder under the build directory (see step 2 in Building ClusterJ with Maven); select the `clusterj` folder, which has the Maven icon ( ) beside it, and click **Open Project**. The `ClusterJ Aggregate` project is imported, with `ClusterJ API`, `ClusterJ Core`, `ClusterJ Test Suite`, `ClusterJ Tie`, and `ClusterJ Unit Test Framework` imported as subprojects under **Modules**.
   - Work with the ClusterJ projects like you would with any other Maven projects in NetBeans. Any changes to the source code go into the source tree from which you compiled NDB Cluster to create the build directory.

   In Eclipse:

   - In the main menu, choose **File** > **Import**. The **Import** dialogue box appears
   - In the **Import** dialogue box, select **Maven** > **Existing Maven Projects** for import wizard and click **Next**. The **Import Maven Projects** dialogue box appears.

- In the **Import Maven Projects** dialogue box, browse to the `storage/ndb` folder under the build directory (see step 2 in Building ClusterJ with Maven); select the `clusterj` folder and click **Select Folder**. The `clusterj-aggregate` project, as well as its subprojects `clusterj-api`, `clusterj-core`, `clusterj-test`, `clusterj-tie` and `clusterj-unit`, appear in the **Maven Projects** dialogue box. Click **Select All** and then **Finish**. All the ClusterJ projects are imported.

- Work with the ClusterJ projects like you would with any other Maven projects in Eclipse.

4.2.2 Using ClusterJ

This section provides basic information for writing, compiling, and executing applications that use ClusterJ. For the API documentation for ClusterJ, see Section 4.3, “ClusterJ API Reference”.

Requirements. ClusterJ requires Java 1.7 or 1.8. *NDB Cluster must be compiled with ClusterJ support*; NDB Cluster binaries supplied by Oracle include ClusterJ support. If you are building NDB Cluster from source, see Building and installing MySQL NDB Cluster Connector for Java from source, for information on configuring the build to enable ClusterJ support.

To compile applications that use ClusterJ, you either need to have the `clusterj-api` jar file in your classpath, or use a Maven dependency manager to install and configure the ClusterJ library in your project.

To run applications that use ClusterJ, you need the `clusterj` runtime jar file; in addition, `libndbclient` must be in the directory specified by `java.library.path`. Section 4.2.2.1, “Executing ClusterJ Applications and Sessions”, provides more information about these requirements.

4.2.2.1 Executing ClusterJ Applications and Sessions

In this section, we discuss how to start ClusterJ applications and the ClusterJ application environment.

Executing a ClusterJ application. All of the ClusterJ jar files are normally found in `share/mysql/java/` in the MySQL installation directory. When executing a ClusterJ application, you must set the classpath to point to these files. In addition, you must set `java.library.path` variable to point to the directory containing the Cluster `ndbclient` library, normally found in `lib/mysql` (also in the MySQL installation directory). Thus you might execute a ClusterJ program `MyClusterJApp` in a manner similar to what is shown here:

```
shell> java -classpath /usr/local/mysql/share/mysql/java/clusterj.jar \
              -Djava.library.path=/usr/local/mysql/lib MyClusterJApp
```

> **Note**
>
> The precise locations of the ClusterJ jar files and of `libndbclient` depend on how the NDB Cluster software was installed. See Installation Layouts, for more information.

ClusterJ encourages you to use different jar files at compile time and runtime. This is to remove the ability of applications to access implementation artifacts accidentally. ClusterJ is intended to be independent of the NDB Cluster software version, whereas the `ndbclient` layer is version-specific. This makes it possible to maintain a stable API, so that applications written against it using a given NDB Cluster version continue to run following an upgrade of the cluster to a new version.

Getting the SessionFactory and getting a Session. `SessionFactory` is the source of all ClusterJ sessions that use a given NDB Cluster. Usually, there is only a single `SessionFactory` per NDB Cluster, per Java Virtual Machine.

`SessionFactory` can be configured by setting one or more properties. The preferred way to do this is by putting these in a properties file, like this:

```
com.mysql.clusterj.connectstring=localhost:1186
com.mysql.clusterj.database=mydb
```

The name of the properties file is arbitrary; however, by convention, such files are named with a `.properties` extension. For ClusterJ applications, it is customary to name the file `clusterj.properties`.

After editing and saving the file, you can load its contents into an instance of `Properties`, as shown here:

```
File propsFile = new File("clusterj.properties");
InputStream inStream = new FileInputStream(propsFile);
Properties props = new Properties();
props.load(inStream);
```

It is also possible to set these properties directly, without the use of a properties file:

```
Properties props = new Properties();

props.put("com.mysql.clusterj.connectstring", "localhost:1186");
props.put("com.mysql.clusterj.database", "mydb");
```

Once the properties have been set and loaded (using either of the techniques just shown), you can obtain a `SessionFactory`, and then from that a `Session` instance. For this, you use the `SessionFactory`'s `getSession()` method, as shown here:

```
SessionFactory factory = ClusterJHelper.getSessionFactory(props);

Session session = factory.getSession();
```

It is usually sufficient to set and load the `com.mysql.clusterj.connectstring` and `com.mysql.clusterj.database` properties (and these properties, along with `com.mysql.clusterj.max.transactions`, cannot be changed after starting the `SessionFactory`). For a complete list of available `SessionFactory` properties and usual values, see com.mysql.clusterj.Constants.

Note

`Session` instances must not be shared among threads. Each thread in your application should use its own instance of `Session`.

For `com.mysql.clusterj.connectstring`, we use the default NDB Cluster connection string `localhost:1186` (see NDB Cluster Connection Strings, for more information). For the value of `com.mysql.clusterj.database`, we use `mydb` in this example, but this value can be the name of any database containing `NDB` tables. For a listing of all `SessionFactory` properties that can be set in this manner, see com.mysql.clusterj.Constants.

Error Handling and Reconnection. Errors that occur while using ClusterJ should be handled by the application with a common error handler. The handler needs to be able to detect and distinguish among three types of errors, and handle them accordingly:

- *Normal errors*: These are errors at the application level (for example, those to deal with duplicate key, foreign key constraint, or timeout). They should be handled in application-specific ways, and, if resolved, the application can continue with the transaction.
- *Unexpected errors*: These are failures to work with the cluster that cannot be accounted for by the conditions of the application, but are nonfatal. The application should close the ClusterJ session and reopen a new one.
- *Connectivity errors*: These are errors like error 4009 and 4010, which indicate a network outage. There are two possible scenarios, depending on whether the automatic reconnection feature

(available for NDB Cluster 7.5.7, 7.6.3, and for later releases in the 7.5 and 7.6 series) has been enabled:

- *Automatic reconnection is enabled :* The feature is enabled when the connection property `com.mysql.clusterj.connection.reconnect.timeout` has been set to a positive number, which specifies a reconnection timeout in seconds.

  When ClusterJ detects a disconnect with the NDB Cluster, it changes the `State` of the `SessionFactory` from `OPEN` to `RECONNECTING`; the `SessionFactory` then waits for the application to close all the sessions, and then attempts to reconnect the application to the NDB Cluster by closing all connections in the connection pool and recreating the pool using the original pool properties. After reestablishing all the connections, the `State` of the `SessionFactory` becomes `OPEN` again, and the application can now obtain sessions.

  The `SessionFactory.getState()` method returns the `State` of the `SessionFactory`, which is one of `OPEN`, `RECONNECTING`, or `CLOSED`. Trying to obtain a session when the `State` is not `OPEN` results in a `ClusterJUserException`, with the message `Session factory is not open`.

  If the application does not close all sessions by the end of the timeout period specified with `com.mysql.clusterj.connection.reconnect.timeout`, the `SessionFactory` closes any open sessions forcibly (which might result in loss of resources), and then attempts reconnection.

- *Automatic reconnection is not enabled:* This is when the connection property `com.mysql.clusterj.connection.reconnect.timeout` has not been set, or it has been set to zero (this is also the case for older NDB Cluster releases that do not support the automatic reconnection feature).

  ClusterJ does not attempt to reconnect to the NDB Cluster once the connection is lost. The application should close all sessions and then restart the `SessionFactory`. The restarting of the `SessionFactory` can be an automatic application function or a manual intervention. In either case, the code should wait until all sessions have been closed (that is, the public method getConnectionPoolSessionCounts() in the `SessionFactory` interface returns zeros for all pooled connections). Then the `SessionFactory` can be closed and reopened, and the application can obtain sessions again.

Instead of enabling the feature and waiting for ClusterJ to detect a disconnection and attempt a reconnection, you can also have the application itself initiate the reconnection process upon the detection of a connection error by calling the `SessionFactory.reconnect(int timeout)` method: that triggers the reconnection process described above, but uses the `timeout` argument of the `reconnect()` method as the time limit for having all open sessions closed.

Logging. ClusterJ uses Java logging. Here are some default settings for the ClusterJ logging, which are specified in the `logging.properties` file and can be modified there:

- Logging level is set at `INFO` for all classes.
- Using `java.util.logging.FileHandler` as the handler.
- Default level for `java.util.logging.FileHandler` is set at `FINEST`
- Using `java.util.logging.SimpleFormatter` as the formatter for the handler.
- Log files are put inside the `target` directory under the current working directory, and file names are, generally, in the pattern of `log`*`Num`*, where *`Num`* is a unique number for resolving file name conflicts (see the Java documentation for `java.util.logging.FileHandler` for details).

The `logging.properties` file is located by default in the current working directory, but the location can be changed by specifying the system property `java.util.logging.config.file` when you start Java.

4.2.2.2 Creating tables

ClusterJ's main purpose is to read, write, and update row data in an existing database, rather than to perform DDL. You can create the `employee` table that matches this interface, using the following `CREATE TABLE` statement, in a MySQL client application such as `mysql`.

```
CREATE TABLE employee (
    id INT NOT NULL PRIMARY KEY,
    first VARCHAR(64) DEFAULT NULL,
    last VARCHAR(64) DEFAULT NULL,
    municipality VARCHAR(64) DEFAULT NULL,
    started DATE DEFAULT NULL,
    ended DATE DEFAULT NULL,
    department INT NOT NULL DEFAULT 1,
    UNIQUE KEY idx_u_hash (last,first USING HASH),
    KEY idx_municipality (municipality)
) ENGINE=NDBCLUSTER;
```

Now that the table has been created in NDB Cluster, you can map a ClusterJ interface to it using annotations. We show you how to do this in the next section.

4.2.2.3 Annotations

In ClusterJ (as in JPA), annotations are used to describe how the interface is mapped to tables in a database. An annotated interface looks like this:

```
@PersistenceCapable(table="employee")
@Index(name="idx_uhash")
public interface Employee {

    @PrimaryKey
    int getId();
    void setId(int id);

    String getFirst();
    void setFirst(String first);
    String getLast();
    void setLast(String last);

    @Column(name="municipality")
    @Index(name="idx_municipality")
    String getCity();
    void setCity(String city);

    Date getStarted();
    void setStarted(Date date);

    Date getEnded();
    void setEnded(Date date);

    Integer getDepartment();
    void setDepartment(Integer department);
}
```

This interface maps seven columns: `id`, `first`, `last`, `municipality` `started`, `ended`, and `department`. The annotation `@PersistenceCapable(table="employee")` is used to let ClusterJ know which database table to map the `Employee` to (in this case, the `employee` table). The `@Column` annotation is used because the `city` property name implied by the `getCity()` and `setCity()` methods is different from the mapped column name `municipality`. The annotations `@PrimaryKey` and `@Index` inform ClusterJ about indexes in the database table.

The implementation of this interface is created dynamically by ClusterJ at runtime. When the `newInstance()` method is called, ClusterJ creates an implementation class for the `Employee` interface; this class stores the values in an internal object array.

ClusterJ does not require an annotation for every attribute. ClusterJ automatically detects the primary keys of tables; while there is an annotation in ClusterJ to permit the user to describe the primary keys of a table (see previous example), when specified, it is currently ignored. (The intended use of this annotation is for the generation of schemas from the domain object model interfaces, but this is not yet supported.)

The annotations themselves must be imported from the ClusterJ API. They can be found in package `com.mysql.clusterj.annotation`, and can be imported like this:

```
import com.mysql.clusterj.annotation.Column;
import com.mysql.clusterj.annotation.Index;
import com.mysql.clusterj.annotation.PersistenceCapable;
import com.mysql.clusterj.annotation.PrimaryKey;
```

4.2.2.4 ClusterJ Basic Operations

In this section, we describe how to perform operations basic to ClusterJ applications, including the following:

- Creating new instances, setting their properties, and saving them to the database
- Performing primary key lookups (reads)
- Updating existing rows and saving the changes to the database
- Deleting rows from the database
- Constructing and executing queries to fetch a set of rows meeting certain criteria from the database

Creating new rows. To insert a new row into the table, first create a new instance of `Employee`. This can be accomplished by calling the `Session` method `newInstance()`, as shown here:

```
Employee newEmployee = session.newInstance(Employee.class);
```

Set the `Employee` instance properties corresponding with the desired `employee` table columns. For example, the following sets the `id`, `firstName`, `lastName`, and `started` properties.

```
emp.setId(988);

newEmployee.setFirstName("John");
newEmployee.setLastName("Jones");

newEmployee.setStarted(new Date());
```

Once you are satisfied with the changes, you can persist the `Employee` instance, causing a new row containing the desired values to be inserted into the `employee` table, like this:

```
session.persist(newEmployee);
```

If autocommit is on, and a row with the same `id` as this instance of `Employee` already exists in the database, the `persist()` method fails. If autocommit is off and a row with the same `id` as this `Employee` instance already exists in the database, the `persist()` method succeeds but a subsequent `commit()` fails.

If you want the data to be saved even though the row already exists, use the `savePersistent()` method instead of the `persist()` method. The `savePersistent()` method updates an existing instance or creates a new instance as needed, without throwing an exception.

Values that you have not specified are stored with their Java default values (`0` for integral types, `0.0` for numeric types, and `null` for reference types).

Primary key lookups. You can find an existing row in an `NDB` table using the `Session`'s `find()` method, like this:

```
Employee theEmployee = session.find(Employee.class, 988);
```

This is equivalent to the primary key lookup query `SELECT * FROM employee WHERE id = 988`.

ClusterJ also supports compound primary keys. The `find()` method can take an object array as a key, where the components of the object array are used to represent the primary key columns in the order they were declared. In addition, queries are optimized to detect whether columns of the primary key are specified as part of the query criteria, and if so, a primary key lookup or scan is executed as a strategy to implement the query.

Note

ClusterJ also supports multiple column ordered btree and unique hash indexes. As with primary keys, if a query specifies values for ordered or unique index fields, ClusterJ optimizes the query to use the index for scanning the table.

NDB Cluster automatically spreads table data across multiple data nodes. For some operations—find, insert, delete, and update—it is more efficient to tell the cluster on which data node the data is physically located, and to have the transaction execute on that data node. ClusterJ automatically detects the partition key; if the operation can be optimized for a specific data node, ClusterJ automatically starts the transaction on that node.

Update and save a row. To update the value of a given column in the row that we just obtained as `theEmployee`, use the `set*()` method whose name corresponds to the name of that column. For example, to update the `started` date for this `Employee`, use the `Employee`'s `setStarted()` method, as shown here:

```
theEmployee.setStarted(new Date(getMillisFor(2010, 01, 04)));
```

Note

For convenience, we use in this example a method `getMillisFor()`, which is defined as shown here, in the file `AbstractClusterJModelTest.java` (found in the `storage/ndb/clusterj/clusterj-test/src/main/java/testsuite/clusterj` directory of the NDB Cluster source tree):

```
/** Convert year, month, day into milliseconds after the Epoch, UTC.
* Set hours, minutes, seconds, and milliseconds to zero.
* @param year the year
* @param month the month (0 for January)
* @param day the day of the month
* @return
*/

protected static long getMillisFor(int year, int month, int day) {
  Calendar calendar = Calendar.getInstance();
  calendar.clear();
  calendar.set(Calendar.YEAR, year);
  calendar.set(Calendar.MONTH, month);
  calendar.set(Calendar.DATE, day);
  calendar.set(Calendar.HOUR, 0);
  calendar.set(Calendar.MINUTE, 0);
  calendar.set(Calendar.SECOND, 0);
  calendar.set(Calendar.MILLISECOND, 0);
  long result = calendar.getTimeInMillis();
  return result;
}
```

See the indicated file for further information.

You can update additional columns by invoking other `Employee` setter methods, like this:

```
theEmployee.setDepartment(3);
```

To save the changed row back to the NDB Cluster database, use the `Session`'s `updatePersistent()` method, like this:

```
session.updatePersistent(theEmployee);
```

Deleting rows. You can delete a single row easily using the `deletePersistent()` method of `Session`. In this example, we find the employee whose ID is 13, then delete this row from the `employee` table:

```
Employee exEmployee = session.find(Employee.class, 13);

session.deletePersistent(exEmployee);'

System.out.println("Deleted employee named " + exEmployee.getFirst()
                 + " " + exEmployee.getLast() + ".");
```

There also exists a method for deleting multiple rows, which provides two options:

1. Delete all rows from a table.

2. Delete an arbitrary collection of rows.

Both kinds of multi-row delete can be performed using the `deletePersistentAll()` method. The first variant of this method acts on a `Class`. For example, the following statement deletes all rows from the `employee` table and returns the number of rows deleted, as shown here:

```
int numberDeleted = session.deletePersistentAll(Employee);

System.out.println("There used to be "  + numberDeleted + " employees, but now there are none.");
```

The call to `deletePersistentAll()` just shown is equivalent to issuing the SQL statement `DELETE FROM employee` in the `mysql` client.

`deletePersistentAll()` can also be used to delete a collection of rows, as shown in this example:

```
//  Assemble the collection of rows to be deleted...

List<Employee> redundancies = new ArrayList<Employee>();

for (int i = 1000; i < 2000; i += 100) {
  Employee redundant = session.newInstance(Employee.class);
  redundant.setId(i);
  redundancies.add(redundant);
}

numberDeleted = session.deletePersistentAll(redundancies);

System.out.println("Deleted " + numberDeleted + " rows.");
```

It is not necessary to find the instances in the database before deleting them.

Writing queries. The ClusterJ `QueryBuilder` interface is used to instantiate queries. The process begins with obtaining an instance of `QueryBuilder`, which is supplied by the current `Session`; we can then obtain a `QueryDefinition`, as shown here:

```
QueryBuilder builder = session.getQueryBuilder();

QueryDomainType<Employee> domain = builder.createQueryDefinition(Employee.class);
```

This is then used to set a column for comparison by the query. Here, we show how to prepare a query that compares the value of the `employee` table's `department` column with the constant value `8`.

```
domain.where( domain.get("department").equal(domain.param("department") );

Query<Employee> query = session.createQuery(domain);

query.setParameter("department", 8);
```

To obtain the results from the query, invoke the `Query`'s `getResultList()` method, as shown here;

```
List<Employee> results = query.getResultList();
```

The return value is a `List` that you can iterate over to retrieve and process the rows in the usual manner.

Transactions. The `Transaction` interface can optionally be used to bound transactions, via the following methods:

- `begin()`: Begin a transaction.
- `commit()`: Commit a transaction.
- `rollback()`: Roll back a transaction.

It is also possible using `Transaction` to check whether the transaction is active (via the `isActive()` method, and to get and set a rollback-only flag (using `getRollbackOnly()` and `setRollbackOnly()`, respectively).

If you do not use the `Transaction` interface, methods in `Session` that affect the database—such as `persist()`, `deletePersistent()`, `updatePersistent()`, and so on—are automatically enclosed in a database transaction.

4.2.2.5 ClusterJ Mappings Between MySQL and Java Data Types

ClusterJ provides mappings for all of the common MySQL database types to Java types. Java object wrappers of primitive types should be mapped to nullable database columns.

Note

Since Java does not have native unsigned data types, `UNSIGNED` columns should be avoided in table schemas if possible.

Compatibility with JDBC mappings. ClusterJ is implemented so as to be bug-compatible with the JDBC driver in terms of mapping from Java types to the database. That is, if you use ClusterJ to store or retrieve data, you obtain the same value as if you used the JDBC driver directly or through JPA.

The following tables show the mappings used by ClusterJ between common Java data types and MySQL column types. Separate tables are provided for numeric, floating-point, and variable-width types.

Numeric types. This table shows the ClusterJ mappings between Java numeric data types and MySQL column types:

Table 4.1 ClusterJ mappings between Java numeric data types and MySQL column types

Java Data Type	MySQL Column Type
`boolean`, `Boolean`	`BIT(1)`
`byte`, `Byte`	`BIT(1)` to `BIT(8)`, `TINYINT`
`short`, `Short`	`BIT(1)` to `BIT(16)`, `SMALLINT`, `YEAR`
`int`, `Integer`	`BIT(1)` to `BIT(32)`, `INT`
`long`, `Long`	`BIT(1)` to `BIT(64)`, `BIGINT`, `BIGINT UNSIGNED`
`float`, `Float`	`FLOAT`
`double`, `Double`	`DOUBLE`
`java.math.BigDecimal`	`NUMERIC`, `DECIMAL`
`java.math.BigInteger`	`NUMERIC` (precision = 0), `DECIMAL` (precision = 0)

Date and time types. The following table shows the ClusterJ mappings between Java date and time data types and MySQL column types:

Table 4.2 ClusterJ mappings between Java date and time data types and MySQL column types

Java Data Type	MySQL Column Type
`Java.util.Date`	`DATETIME`, `TIMESTAMP`, `TIME`, `DATE`
`Java.sql.Date`	`DATE`
`Java.sql.Time`	`TIME`
`Java.sql.Timestamp`	`DATETIME`, `TIMESTAMP`

Note

ClusterJ maps the MySQL `YEAR` type to a Java `short` (or `java.lang.Short`), as shown in the first table in this section.

`java.util.Date` represents date and time similar to the way in which Unix does so, but with more precision and a larger range. Where Unix represents a point in time as a 32-bit signed number of seconds since the Unix Epoch (01 January 1970), Java uses a 64-bit signed number of milliseconds since the Epoch.

Variable-width types. The following table shows the ClusterJ mappings between Java data types and MySQL variable-width column types:

Table 4.3 This table shows the ClusterJ mappings between Java data types and MySQL variable-width column types.

Java Data Type	MySQL Column Type
`String`	`CHAR`, `VARCHAR`, `TEXT`
`byte[]`	`BINARY`, `VARBINARY`, `BLOB`

Note

No translation binary data is performed when mapping from MySQL `BINARY`, `VARBINARY`, or `BLOB` column values to Java byte arrays. Data is presented to the application exactly as it is stored.

4.2.3 Using Connector/J with NDB Cluster

JDBC clients of an NDB Cluster data source, and using Connector/J 5.0.6 (or later), accept `jdbc:mysql:loadbalance://` URLs (see Configuration Properties for Connector/J), with which you can take advantage of the ability to connect with multiple MySQL servers to achieve load balancing and failover.

However, while Connector/J does not depend on the MySQL client libraries, it does require a connection to a MySQL Server, which ClusterJ does not. JDBC also does not provide any object mappings for database objects, properties, or operations, or any way to persist objects.

See MySQL Connector/J 5.1 Developer Guide, for general information about using Connector/J.

4.3 ClusterJ API Reference

The following sections contain specifications for ClusterJ packages, interfaces, classes, and methods.

4.3.1 com.mysql.clusterj

Provides classes and interfaces for using NDB Cluster directly from Java.

- A class for bootstrapping

- Interfaces for use in application programs
- Classes to define exceptions

This package contains three main groups of classes and interfaces:

4.3.1.1 Major Interfaces

ClusterJ provides these major interfaces for use by application programs: `com.mysql.clusterj.SessionFactory`, `com.mysql.clusterj.Session`, `com.mysql.clusterj.Transaction`, `com.mysql.clusterj.query.QueryBuilder`, and `com.mysql.clusterj.Query`. *Bootstrapping* The helper class `com.mysql.clusterj.ClusterJHelper` contains methods for creating the `com.mysql.clusterj.SessionFactory`. *Bootstrapping* is the process of identifying an NDB Cluster and obtaining the SessionFactory for use with the cluster. There is one SessionFactory per cluster per Java VM.

SessionFactory

The `com.mysql.clusterj.SessionFactory` is configured via properties, which identify the NDB Cluster that the application connects to:

- com.mysql.clusterj.connectstring identifies the ndb_mgmd host name and port
- com.mysql.clusterj.connect.retries is the number of retries when connecting
- com.mysql.clusterj.connect.delay is the delay in seconds between connection retries
- com.mysql.clusterj.connect.verbose tells whether to display a message to System.out while connecting
- com.mysql.clusterj.connect.timeout.before is the number of seconds to wait until the first node responds to a connect request
- com.mysql.clusterj.connect.timeout.after is the number of seconds to wait until the last node responds to a connect request
- com.mysql.clusterj.connect.database is the name of the database to use

```
File propsFile = new File("clusterj.properties");
InputStream inStream = new FileInputStream(propsFile);
Properties props = new Properties();
props.load(inStream);
SessionFactory sessionFactory = ClusterJHelper.getSessionFactory(props);
```

Session The `com.mysql.clusterj.Session` represents the user's individual connection to the cluster. It contains methods for:

- finding persistent instances by primary key
- persistent instance factory (newInstance)
- persistent instance life cycle management (persist, remove)
- getting the QueryBuilder
- getting the Transaction (currentTransaction)

```
Session session = sessionFactory.getSession();
Employee existing = session.find(Employee.class, 1);
if (existing != null) {
    session.remove(existing);
}
Employee newemp = session.newInstance(Employee.class);
```

```
    newemp.initialize(2, "Craig", 15, 146000.00);
    session.persist(newemp);
```

Transaction The `com.mysql.clusterj.Transaction` allows users to combine multiple operations into a single database transaction. It contains methods to:

- begin a unit of work
- commit changes from a unit of work
- roll back all changes made since the unit of work was begun
- mark a unit of work for rollback only
- get the rollback status of the current unit of work

```
    Transaction tx = session.currentTransaction();
    tx.begin();
    Employee existing = session.find(Employee.class, 1);
    Employee newemp = session.newInstance(Employee.class);
    newemp.initialize(2, "Craig", 146000.00);
    session.persist(newemp);
    tx.commit();
```

QueryBuilder The `com.mysql.clusterj.query.QueryBuilder` allows users to build queries. It contains methods to:

- define the Domain Object Model to query
- compare properties with parameters using:
  - equal
  - lessThan
  - greaterThan
  - lessEqual
  - greaterEqual
  - between
  - in
- combine comparisons using "and", "or", and "not" operators

```
    QueryBuilder builder = session.getQueryBuilder();
    QueryDomainType<Employee> qemp = builder.createQueryDefinition(Employee.class);
    Predicate service = qemp.get("yearsOfService").greaterThan(qemp.param("service"));
    Predicate salary = qemp.get("salary").lessEqual(qemp.param("salaryCap"));
    qemp.where(service.and(salary));
    Query<Employee> query = session.createQuery(qemp);
    query.setParameter("service", 10);
    query.setParameter("salaryCap", 180000.00);
    List<Employee> results = query.getResultList();
```

4.3.1.2 ClusterJDatastoreException

ClusterJUserException represents a database error. The underlying cause of the exception is contained in the "cause".

Synopsis

```
public class ClusterJDatastoreException,
  extends  ClusterJException {
```

```
// Public Constructors

  public ClusterJDatastoreException(
    String message);

  public ClusterJDatastoreException(
    String msg,
    int code,
    int mysqlCode,
    int status,
    int classification);

  public ClusterJDatastoreException(
    String message,
    Throwable t);

  public ClusterJDatastoreException(
    Throwable t);

// Public Methods

  public int getClassification();

  public int getCode();

  public int getMysqlCode();

  public int getStatus();

}
```

Methods inherited from com.mysql.clusterj.ClusterJException: `printStackTrace`

Methods inherited from java.lang.Throwable: `addSuppressed` , `fillInStackTrace` , `getCause` , `getLocalizedMessage` , `getMessage` , `getStackTrace` , `getSuppressed` , `initCause` , `setStackTrace` , `toString`

Methods inherited from java.lang.Object: `equals` , `getClass` , `hashCode` , `notify` , `notifyAll` , `wait`

getClassification()

```
  public int getClassification();
```

Get the classification

getCode()

```
  public int getCode();
```

Get the code

Since	7.3.15, 7.4.13, 7.5.4

getMysqlCode()

```
  public int getMysqlCode();
```

Get the mysql code

Since	7.3.15, 7.4.13, 7.5.4

getStatus()

```
  public int getStatus();
```

Get the status

4.3.1.3 ClusterJDatastoreException.Classification

Helper class for getClassification(). import com.mysql.clusterj.ClusterJDatastoreException.Classification; Classification c = Classification.lookup(datastoreException.getClassification()); System.out.println("exceptionClassification " + c + " with value " + c.value);

Synopsis

```
public static final class ClusterJDatastoreException.Classification,
  extends  Enum<Classification> {
// Public Static Fields

  public static final Classification
    ApplicationError ;

  public static final Classification
    ConstraintViolation ;

  public static final Classification
    FunctionNotImplemented ;

  public static final Classification
    InsufficientSpace ;

  public static final Classification
    InternalError ;

  public static final Classification
    InternalTemporary ;

  public static final Classification
    NoDataFound ;

  public static final Classification
    NoError ;

  public static final Classification
    NodeRecoveryError ;

  public static final Classification
    NodeShutdown ;

  public static final Classification
    OverloadError ;

  public static final Classification
    SchemaError ;

  public static final Classification
    SchemaObjectExists ;

  public static final Classification
    TemporaryResourceError ;

  public static final Classification
    TimeoutExpired ;

  public static final Classification
    UnknownErrorCode ;

  public static final Classification
    UnknownResultError ;

  public static final Classification
    UserDefinedError ;

// Public Static Methods

  public static Classification lookup(
    int value);
```

```
  public static Classification valueOf(
    String name);

  public static Classification[] values();

}
```

Methods inherited from java.lang.Enum: `compareTo` , `equals` , `getDeclaringClass` , `hashCode` , `name` , `ordinal` , `toString` , `valueOf`

Methods inherited from java.lang.Object: `getClass` , `notify` , `notifyAll` , `wait`

Since	7.3.15, 7.4.13, 7.5.4

lookup(int)

```
  public static Classification lookup(
    int value);
```

Get the Classification enum for a value returned by ClusterJDatastoreException.getClassification().

Table 4.4 lookup(int)

Parameter	Description
value	the classification returned by getClassification()
return	the Classification for the error

4.3.1.4 ClusterJException

ClusterJException is the base for all ClusterJ exceptions. Applications can catch ClusterJException to be notified of all ClusterJ reported issues.

- User exceptions are caused by user error, for example providing a connect string that refers to an unavailable host or port.
  - If a user exception is detected during bootstrapping (acquiring a SessionFactory), it is thrown as a fatal exception. `com.mysql.clusterj.ClusterJFatalUserException`
  - If an exception is detected during initialization of a persistent interface, for example annotating a column that doesn't exist in the mapped table, it is reported as a user exception. `com.mysql.clusterj.ClusterJUserException`
- Datastore exceptions report conditions that result from datastore operations after bootstrapping. For example, duplicate keys on insert, or record does not exist on delete. `com.mysql.clusterj.ClusterJDatastoreException`
- Internal exceptions report conditions that are caused by errors in implementation. These exceptions should be reported as bugs. `com.mysql.clusterj.ClusterJFatalInternalException`

Exceptions are in three general categories: User exceptions, Datastore exceptions, and Internal exceptions.

Synopsis

```
public class ClusterJException,
  extends  RuntimeException {
// Public Constructors

  public ClusterJException(
    String message);

  public ClusterJException(
    String message,
    Throwable t);
```

```
  public ClusterJException(
    Throwable t);

// Public Methods

  public synchronized void printStackTrace(
    PrintStream s);

}
```

Direct known subclasses: `com.mysql.clusterj.ClusterJDatastoreException` , `com.mysql.clusterj.ClusterJFatalException` , `com.mysql.clusterj.ClusterJUserException`

Methods inherited from java.lang.Throwable: `addSuppressed` , `fillInStackTrace` , `getCause` , `getLocalizedMessage` , `getMessage` , `getStackTrace` , `getSuppressed` , `initCause` , `printStackTrace` , `setStackTrace` , `toString`

Methods inherited from java.lang.Object: `equals` , `getClass` , `hashCode` , `notify` , `notifyAll` , `wait`

4.3.1.5 ClusterJFatalException

ClusterJFatalException represents an exception that is not recoverable.

Synopsis

```
public class ClusterJFatalException,
  extends  ClusterJException {
// Public Constructors

  public ClusterJFatalException(
    String string);

  public ClusterJFatalException(
    String string,
    Throwable t);

  public ClusterJFatalException(
    Throwable t);

}
```

Direct known subclasses: `com.mysql.clusterj.ClusterJFatalInternalException` , `com.mysql.clusterj.ClusterJFatalUserException`

Methods inherited from com.mysql.clusterj.ClusterJException: `printStackTrace`

Methods inherited from java.lang.Throwable: `addSuppressed` , `fillInStackTrace` , `getCause` , `getLocalizedMessage` , `getMessage` , `getStackTrace` , `getSuppressed` , `initCause` , `setStackTrace` , `toString`

Methods inherited from java.lang.Object: `equals` , `getClass` , `hashCode` , `notify` , `notifyAll` , `wait`

4.3.1.6 ClusterJFatalInternalException

ClusterJFatalInternalException represents an implementation error that the user cannot recover from.

Synopsis

```
public class ClusterJFatalInternalException,
  extends  ClusterJFatalException {
// Public Constructors

  public ClusterJFatalInternalException(
    String string);
```

```
  public ClusterJFatalInternalException(
    String string,
    Throwable t);

  public ClusterJFatalInternalException(
    Throwable t);

}
```

Methods inherited from com.mysql.clusterj.ClusterJException: printStackTrace

Methods inherited from java.lang.Throwable: addSuppressed , fillInStackTrace , getCause , getLocalizedMessage , getMessage , getStackTrace , getSuppressed , initCause , setStackTrace , toString

Methods inherited from java.lang.Object: equals , getClass , hashCode , notify , notifyAll , wait

4.3.1.7 ClusterJFatalUserException

ClusterJFatalUserException represents a user error that is unrecoverable, such as programming errors in persistent classes or missing resources in the execution environment.

Synopsis

```
public class ClusterJFatalUserException,
  extends  ClusterJFatalException {
// Public Constructors

  public ClusterJFatalUserException(
    String string);

  public ClusterJFatalUserException(
    String string,
    Throwable t);

  public ClusterJFatalUserException(
    Throwable t);

}
```

Methods inherited from com.mysql.clusterj.ClusterJException: printStackTrace

Methods inherited from java.lang.Throwable: addSuppressed , fillInStackTrace , getCause , getLocalizedMessage , getMessage , getStackTrace , getSuppressed , initCause , setStackTrace , toString

Methods inherited from java.lang.Object: equals , getClass , hashCode , notify , notifyAll , wait

4.3.1.8 ClusterJHelper

ClusterJHelper provides helper methods to bridge between the API and the implementation.

Synopsis

```
public class ClusterJHelper {
// Public Constructors

  public ClusterJHelper();

// Public Static Methods

  public static boolean getBooleanProperty(
    String propertyName,
    String def);
```

```
    public static T getServiceInstance(
      Class<T> cls);

    public static T getServiceInstance(
      Class<T> cls,
      ClassLoader loader);

    public static T getServiceInstance(
      Class<T> cls,
      String implementationClassName);

    public static T getServiceInstance(
      Class<T> cls,
      String implementationClassName,
      ClassLoader loader);

    public static List<T> getServiceInstances(
      Class<T> cls,
      ClassLoader loader,
      StringBuffer errorMessages);

    public static SessionFactory getSessionFactory(
      Map props);

    public static SessionFactory getSessionFactory(
      Map props,
      ClassLoader loader);

    public static String getStringProperty(
      String propertyName,
      String def);

    public static Dbug newDbug();

}
```

Methods inherited from java.lang.Object: `equals` , `getClass` , `hashCode` , `notify` , `notifyAll` , `toString` , `wait`

getBooleanProperty(String, String)

```
    public static boolean getBooleanProperty(
      String propertyName,
      String def);
```

Get the named boolean property from either the environment or system properties. If the property is not 'true' then return false.

Table 4.5 getBooleanProperty(String, String)

Parameter	Description
propertyName	the name of the property
def	the default if the property is not set
return	the system property if it is set via -D or the system environment

getServiceInstance(Class<T>)

```
    public static T getServiceInstance(
      Class<T> cls);
```

Locate a service implementation by services lookup of the context class loader.

Table 4.6 getServiceInstance(Class<T>)

Parameter	Description
cls	the class of the factory

Parameter	Description
return	the service instance

getServiceInstance(Class<T>, ClassLoader)

```
public static T getServiceInstance(
  Class<T> cls,
  ClassLoader loader);
```

Locate a service implementation for a service by services lookup of a specific class loader. The first service instance found is returned.

Table 4.7 getServiceInstance(Class<T>, ClassLoader)

Parameter	Description
cls	the class of the factory
loader	the class loader for the factory implementation
return	the service instance

getServiceInstance(Class<T>, String)

```
public static T getServiceInstance(
  Class<T> cls,
  String implementationClassName);
```

Locate a service implementation for a service. If the implementation name is not null, use it instead of looking up. If the implementation class is not loadable or does not implement the interface, throw an exception. Use the ClusterJHelper class loader to find the service.

Table 4.8 getServiceInstance(Class<T>, String)

Parameter	Description
cls	
implementationClassName	
return	the implementation instance for a service

getServiceInstance(Class<T>, String, ClassLoader)

```
public static T getServiceInstance(
  Class<T> cls,
  String implementationClassName,
  ClassLoader loader);
```

Locate a service implementation for a service. If the implementation name is not null, use it instead of looking up. If the implementation class is not loadable or does not implement the interface, throw an exception.

Table 4.9 getServiceInstance(Class<T>, String, ClassLoader)

Parameter	Description
cls	
implementationClassName	name of implementation class to load
loader	the ClassLoader to use to find the service
return	the implementation instance for a service

getServiceInstances(Class<T>, ClassLoader, StringBuffer)

```
public static List<T> getServiceInstances(
```

```
    Class<T> cls,
    ClassLoader loader,
    StringBuffer errorMessages);
```

Locate all service implementations by services lookup of a specific class loader. Implementations in the services file are instantiated and returned. Failed instantiations are remembered in the errorMessages buffer.

Table 4.10 getServiceInstances(Class<T>, ClassLoader, StringBuffer)

Parameter	Description
cls	the class of the factory
loader	the class loader for the factory implementation
errorMessages	a buffer used to hold the error messages
return	the service instance

getSessionFactory(Map)

```
  public static SessionFactory getSessionFactory(
    Map props);
```

Locate a SessionFactory implementation by services lookup. The class loader used is the thread's context class loader.

Table 4.11 getSessionFactory(Map)

Parameter	Description
props	properties of the session factory
return	the session factory

Exceptions

`ClusterFatalUserException` if the connection to the cluster cannot be made

getSessionFactory(Map, ClassLoader)

```
  public static SessionFactory getSessionFactory(
    Map props,
    ClassLoader loader);
```

Locate a SessionFactory implementation by services lookup of a specific class loader. The properties are a Map that might contain implementation-specific properties plus standard properties.

Table 4.12 getSessionFactory(Map, ClassLoader)

Parameter	Description
props	the properties for the factory
loader	the class loader for the factory implementation
return	the session factory

Exceptions

`ClusterFatalUserException` if the connection to the cluster cannot be made

getStringProperty(String, String)

```
  public static String getStringProperty(
    String propertyName,
    String def);
```

Get the named String property from either the environment or system properties.

Table 4.13 getStringProperty(String, String)

Parameter	Description
propertyName	the name of the property
def	the default if the property is not set
return	the system property if it is set via -D or the system environment

newDbug()

```
public static Dbug newDbug();
```

Return a new Dbug instance.

Table 4.14 newDbug()

Parameter	Description
return	a new Dbug instance

4.3.1.9 ClusterJUserException

ClusterJUserException represents a user programming error.

Synopsis

```
public class ClusterJUserException,
  extends  ClusterJException {
// Public Constructors

  public ClusterJUserException(
    String message);

  public ClusterJUserException(
    String message,
    Throwable t);

  public ClusterJUserException(
    Throwable t);

}
```

Methods inherited from com.mysql.clusterj.ClusterJException: `printStackTrace`

Methods inherited from java.lang.Throwable: `addSuppressed` , `fillInStackTrace` , `getCause` , `getLocalizedMessage` , `getMessage` , `getStackTrace` , `getSuppressed` , `initCause` , `setStackTrace` , `toString`

Methods inherited from java.lang.Object: `equals` , `getClass` , `hashCode` , `notify` , `notifyAll` , `wait`

4.3.1.10 ColumnMetadata

```
public interface ColumnMetadata {
// Public Methods

  public abstract String charsetName();

  public abstract ColumnType columnType();

  public abstract boolean isPartitionKey();

  public abstract boolean isPrimaryKey();

  public abstract Class<?> javaType();
```

```
  public abstract int maximumLength();

  public abstract String name();

  public abstract boolean nullable();

  public abstract int number();

  public abstract int precision();

  public abstract int scale();

}
```

charsetName()

```
  public abstract String charsetName();
```

Return the charset name.

Table 4.15 charsetName()

Parameter	Description
return	the charset name

columnType()

```
  public abstract ColumnType columnType();
```

Return the type of the column.

Table 4.16 columnType()

Parameter	Description
return	the type of the column

isPartitionKey()

```
  public abstract boolean isPartitionKey();
```

Return whether this column is a partition key column.

Table 4.17 isPartitionKey()

Parameter	Description
return	true if this column is a partition key column

isPrimaryKey()

```
  public abstract boolean isPrimaryKey();
```

Return whether this column is a primary key column.

Table 4.18 isPrimaryKey()

Parameter	Description
return	true if this column is a primary key column

javaType()

```
  public abstract Class<?> javaType();
```

Return the java type of the column.

Table 4.19 javaType()

Parameter	Description
return	the java type of the column

maximumLength()

```
public abstract int maximumLength();
```

Return the maximum number of bytes that can be stored in the column after translating the characters using the character set.

Table 4.20 maximumLength()

Parameter	Description
return	the maximum number of bytes that can be stored in the column

name()

```
public abstract String name();
```

Return the name of the column.

Table 4.21 name()

Parameter	Description
return	the name of the column

nullable()

```
public abstract boolean nullable();
```

Return whether this column is nullable.

Table 4.22 nullable()

Parameter	Description
return	whether this column is nullable

number()

```
public abstract int number();
```

Return the column number. This number is used as the first parameter in the get and set methods of DynamicColumn.

Table 4.23 number()

Parameter	Description
return	the column number.

precision()

```
public abstract int precision();
```

Return the precision of the column.

Table 4.24 precision()

Parameter	Description
return	the precision of the column

scale()

```
public abstract int scale();
```

Return the scale of the column.

Table 4.25 scale()

Parameter	Description
return	the scale of the column

4.3.1.11 ColumnType

This class enumerates the column types for columns in ndb.

Synopsis

```
public final class ColumnType,
  extends  Enum<ColumnType> {
// Public Static Fields

  public static final ColumnType
    Bigint ;

  public static final ColumnType
    Bigunsigned ;

  public static final ColumnType
    Binary ;

  public static final ColumnType
    Bit ;

  public static final ColumnType
    Blob ;

  public static final ColumnType
    Char ;

  public static final ColumnType
    Date ;

  public static final ColumnType
    Datetime ;

  public static final ColumnType
    Datetime2 ;

  public static final ColumnType
    Decimal ;

  public static final ColumnType
    Decimalunsigned ;

  public static final ColumnType
    Double ;

  public static final ColumnType
    Float ;

  public static final ColumnType
    Int ;

  public static final ColumnType
    Longvarbinary ;

  public static final ColumnType
    Longvarchar ;
```

```
  public static final ColumnType
    Mediumint ;

  public static final ColumnType
    Mediumunsigned ;

  public static final ColumnType
    Olddecimal ;

  public static final ColumnType
    Olddecimalunsigned ;

  public static final ColumnType
    Smallint ;

  public static final ColumnType
    Smallunsigned ;

  public static final ColumnType
    Text ;

  public static final ColumnType
    Time ;

  public static final ColumnType
    Time2 ;

  public static final ColumnType
    Timestamp ;

  public static final ColumnType
    Timestamp2 ;

  public static final ColumnType
    Tinyint ;

  public static final ColumnType
    Tinyunsigned ;

  public static final ColumnType
    Undefined ;

  public static final ColumnType
    Unsigned ;

  public static final ColumnType
    Varbinary ;

  public static final ColumnType
    Varchar ;

  public static final ColumnType
    Year ;

// Public Static Methods

  public static ColumnType valueOf(
    String name);

  public static ColumnType[] values();

}
```

Methods inherited from java.lang.Enum: `compareTo` , `equals` , `getDeclaringClass` , `hashCode` , `name` , `ordinal` , `toString` , `valueOf`

Methods inherited from java.lang.Object: `getClass` , `notify` , `notifyAll` , `wait`

4.3.1.12 Constants

Constants used in the ClusterJ project.

Synopsis

```
public interface Constants {
// Public Static Fields

  public static final String
    DEFAULT_PROPERTY_CLUSTER_BYTE_BUFFER_POOL_SIZES
        =  "256, 10240, 102400, 1048576";

  public static final int
    DEFAULT_PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_BATCH_SIZE
        =  10;

  public static final long
    DEFAULT_PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_START
        =  1L;

  public static final long
    DEFAULT_PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_STEP
        =  1L;

  public static final int
    DEFAULT_PROPERTY_CLUSTER_CONNECT_DELAY
        =  5;

  public static final int
    DEFAULT_PROPERTY_CLUSTER_CONNECT_RETRIES
        =  4;

  public static final int
    DEFAULT_PROPERTY_CLUSTER_CONNECT_TIMEOUT_AFTER
        =  20;

  public static final int
    DEFAULT_PROPERTY_CLUSTER_CONNECT_TIMEOUT_BEFORE
        =  30;

  public static final int
    DEFAULT_PROPERTY_CLUSTER_CONNECT_TIMEOUT_MGM
        =  30000;

  public static final int
    DEFAULT_PROPERTY_CLUSTER_CONNECT_VERBOSE
        =  0;

  public static final String
    DEFAULT_PROPERTY_CLUSTER_DATABASE
        =  "test";

  public static final int
    DEFAULT_PROPERTY_CLUSTER_MAX_TRANSACTIONS
        =  4;

  public static final int
    DEFAULT_PROPERTY_CONNECTION_POOL_RECV_THREAD_ACTIVATION_THRESHOLD
        =  8;

  public static final int
    DEFAULT_PROPERTY_CONNECTION_POOL_SIZE
        =  1;

  public static final int
    DEFAULT_PROPERTY_CONNECTION_RECONNECT_TIMEOUT
        =  0;

  public static final String
    ENV_CLUSTERJ_LOGGER_FACTORY_NAME
        =  "CLUSTERJ_LOGGER_FACTORY";

  public static final String
    PROPERTY_CLUSTER_BYTE_BUFFER_POOL_SIZES
```

```
      =  "com.mysql.clusterj.byte.buffer.pool.sizes";

public static final String
  PROPERTY_CLUSTER_CONNECTION_SERVICE
      =  "com.mysql.clusterj.connection.service";

public static final String
  PROPERTY_CLUSTER_CONNECTSTRING
      =  "com.mysql.clusterj.connectstring";

public static final String
  PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_BATCH_SIZE
      =  "com.mysql.clusterj.connect.autoincrement.batchsize";

public static final String
  PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_START
      =  "com.mysql.clusterj.connect.autoincrement.offset";

public static final String
  PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_STEP
      =  "com.mysql.clusterj.connect.autoincrement.increment";

public static final String
  PROPERTY_CLUSTER_CONNECT_DELAY
      =  "com.mysql.clusterj.connect.delay";

public static final String
  PROPERTY_CLUSTER_CONNECT_RETRIES
      =  "com.mysql.clusterj.connect.retries";

public static final String
  PROPERTY_CLUSTER_CONNECT_TIMEOUT_AFTER
      =  "com.mysql.clusterj.connect.timeout.after";

public static final String
  PROPERTY_CLUSTER_CONNECT_TIMEOUT_BEFORE
      =  "com.mysql.clusterj.connect.timeout.before";

public static final String
  PROPERTY_CLUSTER_CONNECT_TIMEOUT_MGM
      =  "com.mysql.clusterj.connect.timeout.mgm";

public static final String
  PROPERTY_CLUSTER_CONNECT_VERBOSE
      =  "com.mysql.clusterj.connect.verbose";

public static final String
  PROPERTY_CLUSTER_DATABASE
      =  "com.mysql.clusterj.database";

public static final String
  PROPERTY_CLUSTER_MAX_TRANSACTIONS
      =  "com.mysql.clusterj.max.transactions";

public static final String
  PROPERTY_CONNECTION_POOL_NODEIDS
      =  "com.mysql.clusterj.connection.pool.nodeids";

public static final String
  PROPERTY_CONNECTION_POOL_RECV_THREAD_ACTIVATION_THRESHOLD
      =  "com.mysql.clusterj.connection.pool.recv.thread.activation.threshold";

public static final String
  PROPERTY_CONNECTION_POOL_RECV_THREAD_CPUIDS
      =  "com.mysql.clusterj.connection.pool.recv.thread.cpuids";

public static final String
  PROPERTY_CONNECTION_POOL_SIZE
      =  "com.mysql.clusterj.connection.pool.size";

public static final String
  PROPERTY_CONNECTION_RECONNECT_TIMEOUT
```

```
        =  "com.mysql.clusterj.connection.reconnect.timeout";

  public static final String
    PROPERTY_DEFER_CHANGES
        =  "com.mysql.clusterj.defer.changes";

  public static final String
    PROPERTY_JDBC_DRIVER_NAME
        =  "com.mysql.clusterj.jdbc.driver";

  public static final String
    PROPERTY_JDBC_PASSWORD
        =  "com.mysql.clusterj.jdbc.password";

  public static final String
    PROPERTY_JDBC_URL
        =  "com.mysql.clusterj.jdbc.url";

  public static final String
    PROPERTY_JDBC_USERNAME
        =  "com.mysql.clusterj.jdbc.username";

  public static final String
    SESSION_FACTORY_SERVICE_CLASS_NAME
        =  "com.mysql.clusterj.SessionFactoryService";

  public static final String
    SESSION_FACTORY_SERVICE_FILE_NAME
        =  "META-INF/services/com.mysql.clusterj.SessionFactoryService";

}
```

DEFAULT_PROPERTY_CLUSTER_BYTE_BUFFER_POOL_SIZES

```
  public static final String
    DEFAULT_PROPERTY_CLUSTER_BYTE_BUFFER_POOL_SIZES
        =  "256, 10240, 102400, 1048576";
```

The default value of the byte buffer pool sizes property: 256, 10K, 100K, 1M

DEFAULT_PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_BATCH_SIZE

```
  public static final int
    DEFAULT_PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_BATCH_SIZE
        =  10;
```

The default value of the connection autoincrement batch size property

DEFAULT_PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_START

```
  public static final long
    DEFAULT_PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_START
        =  1L;
```

The default value of the connection autoincrement start property

DEFAULT_PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_STEP

```
  public static final long
    DEFAULT_PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_STEP
        =  1L;
```

The default value of the connection autoincrement step property

DEFAULT_PROPERTY_CLUSTER_CONNECT_DELAY

```
  public static final int
    DEFAULT_PROPERTY_CLUSTER_CONNECT_DELAY
        =  5;
```

The default value of the connection delay property

DEFAULT_PROPERTY_CLUSTER_CONNECT_RETRIES

```
public static final int
  DEFAULT_PROPERTY_CLUSTER_CONNECT_RETRIES
      =  4;
```

The default value of the connection retries property

DEFAULT_PROPERTY_CLUSTER_CONNECT_TIMEOUT_AFTER

```
public static final int
  DEFAULT_PROPERTY_CLUSTER_CONNECT_TIMEOUT_AFTER
      =  20;
```

The default value of the connection timeout after property

DEFAULT_PROPERTY_CLUSTER_CONNECT_TIMEOUT_BEFORE

```
public static final int
  DEFAULT_PROPERTY_CLUSTER_CONNECT_TIMEOUT_BEFORE
      =  30;
```

The default value of the connection timeout before property

DEFAULT_PROPERTY_CLUSTER_CONNECT_TIMEOUT_MGM

```
public static final int
  DEFAULT_PROPERTY_CLUSTER_CONNECT_TIMEOUT_MGM
      =  30000;
```

The default value of the connection timeout mgm property

DEFAULT_PROPERTY_CLUSTER_CONNECT_VERBOSE

```
public static final int
  DEFAULT_PROPERTY_CLUSTER_CONNECT_VERBOSE
      =  0;
```

The default value of the connection verbose property

DEFAULT_PROPERTY_CLUSTER_DATABASE

```
public static final String
  DEFAULT_PROPERTY_CLUSTER_DATABASE
      =  "test";
```

The default value of the database property

DEFAULT_PROPERTY_CLUSTER_MAX_TRANSACTIONS

```
public static final int
  DEFAULT_PROPERTY_CLUSTER_MAX_TRANSACTIONS
      =  4;
```

The default value of the maximum number of transactions property

DEFAULT_PROPERTY_CONNECTION_POOL_RECV_THREAD_ACTIVATION_THRESHOLD

```
public static final int
  DEFAULT_PROPERTY_CONNECTION_POOL_RECV_THREAD_ACTIVATION_THRESHOLD
      =  8;
```

The default value of the receive thread activation threshold

DEFAULT_PROPERTY_CONNECTION_POOL_SIZE

```
public static final int
  DEFAULT_PROPERTY_CONNECTION_POOL_SIZE
      =  1;
```

The default value of the connection pool size property

DEFAULT_PROPERTY_CONNECTION_RECONNECT_TIMEOUT

```
public static final int
  DEFAULT_PROPERTY_CONNECTION_RECONNECT_TIMEOUT
      =  0;
```

Since 7.5.7

The default value of the connection reconnect timeout property. The default means that the automatic reconnection due to network failures is disabled.

ENV_CLUSTERJ_LOGGER_FACTORY_NAME

```
public static final String
  ENV_CLUSTERJ_LOGGER_FACTORY_NAME
      =  "CLUSTERJ_LOGGER_FACTORY";
```

The name of the environment variable to set the logger factory

PROPERTY_CLUSTER_BYTE_BUFFER_POOL_SIZES

```
public static final String
  PROPERTY_CLUSTER_BYTE_BUFFER_POOL_SIZES
      =  "com.mysql.clusterj.byte.buffer.pool.sizes";
```

The name of the byte buffer pool sizes property. To disable buffer pooling for blob objects, set the value of this property to "1". With this setting, buffers will be allocated and freed (and cleaned if possible) immediately after being used for blob data transfer.

PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_BATCH_SIZE

```
public static final String
  PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_BATCH_SIZE
      =  "com.mysql.clusterj.connect.autoincrement.batchsize";
```

The name of the connection autoincrement batch size property.

PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_START

```
public static final String
  PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_START
      =  "com.mysql.clusterj.connect.autoincrement.offset";
```

The name of the connection autoincrement start property.

PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_STEP

```
public static final String
  PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_STEP
      =  "com.mysql.clusterj.connect.autoincrement.increment";
```

The name of the connection autoincrement step property.

PROPERTY_CLUSTER_CONNECT_DELAY

```
public static final String
  PROPERTY_CLUSTER_CONNECT_DELAY
      =  "com.mysql.clusterj.connect.delay";
```

The name of the connection delay property. For details, see Ndb_cluster_connection::connect()

PROPERTY_CLUSTER_CONNECT_RETRIES

```
public static final String
  PROPERTY_CLUSTER_CONNECT_RETRIES
      =  "com.mysql.clusterj.connect.retries";
```

The name of the connection retries property. For details, see Ndb_cluster_connection::connect()

PROPERTY_CLUSTER_CONNECT_TIMEOUT_AFTER

```
public static final String
  PROPERTY_CLUSTER_CONNECT_TIMEOUT_AFTER
      =  "com.mysql.clusterj.connect.timeout.after";
```

The name of the connection timeout after property. For details, see Ndb_cluster_connection::wait_until_ready()

PROPERTY_CLUSTER_CONNECT_TIMEOUT_BEFORE

```
public static final String
  PROPERTY_CLUSTER_CONNECT_TIMEOUT_BEFORE
      =  "com.mysql.clusterj.connect.timeout.before";
```

The name of the connection timeout before property. For details, see Ndb_cluster_connection::wait_until_ready()

PROPERTY_CLUSTER_CONNECT_TIMEOUT_MGM

```
public static final String
  PROPERTY_CLUSTER_CONNECT_TIMEOUT_MGM
      =  "com.mysql.clusterj.connect.timeout.mgm";
```

The name of the initial timeout for cluster connection to connect to MGM before connecting to data nodes Ndb_cluster_connection::set_timeout()

PROPERTY_CLUSTER_CONNECT_VERBOSE

```
public static final String
  PROPERTY_CLUSTER_CONNECT_VERBOSE
      =  "com.mysql.clusterj.connect.verbose";
```

The name of the connection verbose property. For details, see Ndb_cluster_connection::connect()

PROPERTY_CLUSTER_CONNECTION_SERVICE

```
public static final String
  PROPERTY_CLUSTER_CONNECTION_SERVICE
      =  "com.mysql.clusterj.connection.service";
```

The name of the connection service property

PROPERTY_CLUSTER_CONNECTSTRING

```
public static final String
  PROPERTY_CLUSTER_CONNECTSTRING
      =  "com.mysql.clusterj.connectstring";
```

The name of the connection string property. For details, see Ndb_cluster_connection constructor

PROPERTY_CLUSTER_DATABASE

```
public static final String
  PROPERTY_CLUSTER_DATABASE
      =  "com.mysql.clusterj.database";
```

The name of the database property. For details, see the catalogName parameter in the Ndb constructor. Ndb constructor

PROPERTY_CLUSTER_MAX_TRANSACTIONS

```
public static final String
  PROPERTY_CLUSTER_MAX_TRANSACTIONS
      =  "com.mysql.clusterj.max.transactions";
```

The name of the maximum number of transactions property. For details, see Ndb::init()

PROPERTY_CONNECTION_POOL_NODEIDS

```
public static final String
  PROPERTY_CONNECTION_POOL_NODEIDS
      =  "com.mysql.clusterj.connection.pool.nodeids";
```

The name of the connection pool node ids property. There is no default. This is the list of node ids to force the connections to be assigned to specific node ids. If this property is specified and connection pool size is not the default, the number of node ids of the list must match the connection pool size, or the number of node ids must be 1 and node ids will be assigned to connections starting with the specified node id.

PROPERTY_CONNECTION_POOL_RECV_THREAD_ACTIVATION_THRESHOLD

```
public static final String
  PROPERTY_CONNECTION_POOL_RECV_THREAD_ACTIVATION_THRESHOLD
      =  "com.mysql.clusterj.connection.pool.recv.thread.activation.threshold";
```

The receive thread activation threshold for all connections in the connection pool. The default is no activation threshold.

PROPERTY_CONNECTION_POOL_RECV_THREAD_CPUIDS

```
public static final String
  PROPERTY_CONNECTION_POOL_RECV_THREAD_CPUIDS
      =  "com.mysql.clusterj.connection.pool.recv.thread.cpuids";
```

The cpu binding of the receive threads for the connections in the connection pool. The default is no cpu binding for receive threads. If this property is specified and connection pool size is not the default (1), the number of cpuids of the list must match the connection pool size.

PROPERTY_CONNECTION_POOL_SIZE

```
public static final String
  PROPERTY_CONNECTION_POOL_SIZE
      =  "com.mysql.clusterj.connection.pool.size";
```

The name of the connection pool size property. This is the number of connections to create in the connection pool. The default is 1 (all sessions share the same connection; all requests for a SessionFactory with the same connect string and database will share a single SessionFactory). A setting of 0 disables pooling; each request for a SessionFactory will receive its own unique SessionFactory.

PROPERTY_CONNECTION_RECONNECT_TIMEOUT

```
public static final String
  PROPERTY_CONNECTION_RECONNECT_TIMEOUT
      =  "com.mysql.clusterj.connection.reconnect.timeout";
```

Since	7.5.7

The number of seconds to wait for all sessions to be closed when reconnecting a SessionFactory due to network failures. The default, 0, indicates that the automatic reconnection to the cluster due to network failures is disabled. Reconnection can be enabled by using the method SessionFactory.reconnect(int timeout) and specifying a new timeout value.

PROPERTY_DEFER_CHANGES

```
public static final String
  PROPERTY_DEFER_CHANGES
      =  "com.mysql.clusterj.defer.changes";
```

The flag for deferred inserts, deletes, and updates

PROPERTY_JDBC_DRIVER_NAME

```
public static final String
  PROPERTY_JDBC_DRIVER_NAME
      =  "com.mysql.clusterj.jdbc.driver";
```

The name of the jdbc driver

PROPERTY_JDBC_PASSWORD

```
public static final String
  PROPERTY_JDBC_PASSWORD
      =  "com.mysql.clusterj.jdbc.password";
```

The jdbc password

PROPERTY_JDBC_URL

```
public static final String
  PROPERTY_JDBC_URL
      =  "com.mysql.clusterj.jdbc.url";
```

The jdbc url

PROPERTY_JDBC_USERNAME

```
public static final String
  PROPERTY_JDBC_USERNAME
      =  "com.mysql.clusterj.jdbc.username";
```

The jdbc username

SESSION_FACTORY_SERVICE_CLASS_NAME

```
public static final String
  SESSION_FACTORY_SERVICE_CLASS_NAME
      =  "com.mysql.clusterj.SessionFactoryService";
```

The name of the session factory service interface

SESSION_FACTORY_SERVICE_FILE_NAME

```
public static final String
  SESSION_FACTORY_SERVICE_FILE_NAME
      =  "META-INF/services/com.mysql.clusterj.SessionFactoryService";
```

The name of the files with names of implementation classes for session factory service

4.3.1.13 Dbug

Dbug allows clusterj applications to enable the DBUG functionality in cluster ndbapi library. The dbug state is a control string that consists of flags separated by colons. Flags are:

- d set the debug flag
- a[,filename] append debug output to the file
- A[,filename] like a[,filename] but flush the output after each operation
- d[,keyword[,keyword...]] enable output from macros with specified keywords

- D[,tenths] delay for specified tenths of a second after each operation
- f[,function[,function...]] limit output to the specified list of functions
- F mark each output with the file name of the source file
- i mark each output with the process id of the current process
- g[,function[,function...]] profile specified list of functions
- L mark each output with the line number of the source file
- n mark each output with the current function nesting depth
- N mark each output with a sequential number
- o[,filename] overwrite debug output to the file
- O[,filename] like o[,filename] but flush the output after each operation
- p[,pid[,pid...]] limit output to specified list of process ids
- P mark each output with the process name
- r reset the indentation level to zero
- t[,depth] limit function nesting to the specified depth
- T mark each output with the current timestamp

For example, the control string to trace calls and output debug information only for "jointx" and overwrite the contents of file "/tmp/dbug/jointx", use "t:d,jointx:o,/tmp/dbug/jointx". The above can be written as ClusterJHelper.newDbug().trace().debug("jointx").output("/tmp/dbug/jointx").set();

Synopsis

```
public interface Dbug {
// Public Methods

  public abstract Dbug append(
    String fileName);

  public abstract Dbug debug(
    String string);

  public abstract Dbug debug(
    String[] strings);

  public abstract Dbug flush();

  public abstract String get();

  public abstract Dbug output(
    String fileName);

  public abstract void pop();

  public abstract void print(
    String keyword,
    String message);

  public abstract void push();

  public abstract void push(
    String state);

  public abstract void set();
```

```
  public abstract void set(
    String state);

  public abstract Dbug trace();

}
```

append(String)

```
public abstract Dbug append(
  String fileName);
```

Specify the file name for debug output (append).

Table 4.26 append(String)

Parameter	Description
fileName	the name of the file
return	this

debug(String)

```
public abstract Dbug debug(
  String string);
```

Set the list of debug keywords.

Table 4.27 debug(String)

Parameter	Description
string	the comma separated debug keywords
return	this

debug(String[])

```
public abstract Dbug debug(
  String[] strings);
```

Set the list of debug keywords.

Table 4.28 debug(String[])

Parameter	Description
strings	the debug keywords
return	this

flush()

```
public abstract Dbug flush();
```

Force flush after each output operation.

Table 4.29 flush()

Parameter	Description
return	this

get()

```
public abstract String get();
```

Return the current state.

Table 4.30 get()

Parameter	Description
return	the current state

output(String)

```
public abstract Dbug output(
  String fileName);
```

Specify the file name for debug output (overwrite).

Table 4.31 output(String)

Parameter	Description
fileName	the name of the file
return	this

pop()

```
public abstract void pop();
```

Pop the current state. The new state will be the previously pushed state.

print(String, String)

```
public abstract void print(
  String keyword,
  String message);
```

Print debug message.

push()

```
public abstract void push();
```

Push the current state as defined by the methods.

push(String)

```
public abstract void push(
  String state);
```

Push the current state and set the parameter as the new state.

Table 4.32 push(String)

Parameter	Description
state	the new state

set()

```
public abstract void set();
```

Set the current state as defined by the methods.

set(String)

```
public abstract void set(
  String state);
```

Set the current state from the parameter.

Table 4.33 set(String)

Parameter	Description
state	the new state

trace()

```
public abstract Dbug trace();
```

Set the trace flag.

Table 4.34 trace()

Parameter	Description
return	this

4.3.1.14 DynamicObject

```
public abstract class DynamicObject {
// Public Constructors

  public DynamicObject();

// Public Methods

  public final ColumnMetadata[] columnMetadata();

  public final DynamicObjectDelegate delegate();

  public final void delegate(
    DynamicObjectDelegate delegate);

  public Boolean found();

  public final Object get(
    int columnNumber);

  public final void set(
    int columnNumber,
    Object value);

  public String table();

}
```

Methods inherited from java.lang.Object: `equals` , `getClass` , `hashCode` , `notify` , `notifyAll` , `toString` , `wait`

4.3.1.15 DynamicObjectDelegate

```
public interface DynamicObjectDelegate {
// Public Methods

  public abstract ColumnMetadata[] columnMetadata();

  public abstract Boolean found();

  public abstract void found(
    Boolean found);

  public abstract Object get(
    int columnNumber);

  public abstract void release();

  public abstract void set(
    int columnNumber,
    Object value);
```

```
  public abstract boolean wasReleased();

}
```

4.3.1.16 LockMode

Lock modes for read operations.

- SHARED: Set a shared lock on rows
- EXCLUSIVE: Set an exclusive lock on rows
- READ_COMMITTED: Set no locks but read the most recent committed values

Synopsis

```
public final class LockMode,
  extends  Enum<LockMode> {
// Public Static Fields

  public static final LockMode
    EXCLUSIVE ;

  public static final LockMode
    READ_COMMITTED ;

  public static final LockMode
    SHARED ;

// Public Static Methods

  public static LockMode valueOf(
    String name);

  public static LockMode[] values();

}
```

Methods inherited from java.lang.Enum: `compareTo` , `equals` , `getDeclaringClass` , `hashCode` , `name` , `ordinal` , `toString` , `valueOf`

Methods inherited from java.lang.Object: `getClass` , `notify` , `notifyAll` , `wait`

4.3.1.17 Query

A Query instance represents a specific query with bound parameters. The instance is created by the method `com.mysql.clusterj.Session.<T>createQuery(com.mysql.clusterj.query.QueryDefinition`

Synopsis

```
public interface Query<E> {
// Public Static Fields

  public static final String
    INDEX_USED
        =  "IndexUsed";

  public static final String
    SCAN_TYPE
        =  "ScanType";

  public static final String
    SCAN_TYPE_INDEX_SCAN
        =  "INDEX_SCAN";

  public static final String
    SCAN_TYPE_PRIMARY_KEY
```

```
        =  "PRIMARY_KEY";

  public static final String
    SCAN_TYPE_TABLE_SCAN
        =  "TABLE_SCAN";

  public static final String
    SCAN_TYPE_UNIQUE_KEY
        =  "UNIQUE_KEY";

// Public Methods

  public abstract int deletePersistentAll();

  public abstract Results<E> execute(
    Object parameter);

  public abstract Results<E> execute(
    Object[] parameters);

  public abstract Results<E> execute(
    Map<String, ?> parameters);

  public abstract Map<String, Object> explain();

  public abstract List<E> getResultList();

  public abstract void setLimits(
    long skip,
    long limit);

  public abstract void setOrdering(
    Ordering ordering,
    String[] orderingFields);

  public abstract void setParameter(
    String parameterName,
    Object value);

}
```

INDEX_USED

```
  public static final String
    INDEX_USED
        =  "IndexUsed";
```

The query explain index used key

SCAN_TYPE

```
  public static final String
    SCAN_TYPE
        =  "ScanType";
```

The query explain scan type key

SCAN_TYPE_INDEX_SCAN

```
  public static final String
    SCAN_TYPE_INDEX_SCAN
        =  "INDEX_SCAN";
```

The query explain scan type value for index scan

SCAN_TYPE_PRIMARY_KEY

```
  public static final String
    SCAN_TYPE_PRIMARY_KEY
        =  "PRIMARY_KEY";
```

The query explain scan type value for primary key

SCAN_TYPE_TABLE_SCAN

```
public static final String
  SCAN_TYPE_TABLE_SCAN
      =  "TABLE_SCAN";
```

The query explain scan type value for table scan

SCAN_TYPE_UNIQUE_KEY

```
public static final String
  SCAN_TYPE_UNIQUE_KEY
      =  "UNIQUE_KEY";
```

The query explain scan type value for unique key

deletePersistentAll()

```
public abstract int deletePersistentAll();
```

Delete the instances that satisfy the query criteria.

Table 4.35 deletePersistentAll()

Parameter	Description
return	the number of instances deleted

execute(Map<String, ?>)

```
public abstract Results<E> execute(
  Map<String, ?> parameters);
```

Execute the query with one or more named parameters. Parameters are resolved by name.

Table 4.36 execute(Map<String, ?>)

Parameter	Description
parameters	the parameters
return	the result

execute(Object...)

```
public abstract Results<E> execute(
  Object[] parameters);
```

Execute the query with one or more parameters. Parameters are resolved in the order they were declared in the query.

Table 4.37 execute(Object...)

Parameter	Description
parameters	the parameters
return	the result

execute(Object)

```
public abstract Results<E> execute(
  Object parameter);
```

Execute the query with exactly one parameter.

Table 4.38 execute(Object)

Parameter	Description
parameter	the parameter
return	the result

explain()

```
public abstract Map<String, Object> explain();
```

Explain how this query will be or was executed. If called before binding all parameters, throws ClusterJUserException. Return a map of key:value pairs that explain how the query will be or was executed. Details can be obtained by calling toString on the value. The following keys are returned:

- ScanType: the type of scan, with values:
  - PRIMARY_KEY: the query used key lookup with the primary key
  - UNIQUE_KEY: the query used key lookup with a unique key
  - INDEX_SCAN: the query used a range scan with a non-unique key
  - TABLE_SCAN: the query used a table scan
- IndexUsed: the name of the index used, if any

Table 4.39 explain()

Parameter	Description
return	the data about the execution of this query

Exceptions

`ClusterJUserException` if not all parameters are bound

getResultList()

```
public abstract List<E> getResultList();
```

Get the results as a list.

Table 4.40 getResultList()

Parameter	Description
return	the result

Exceptions

`ClusterJUserException` if not all parameters are bound

`ClusterJDatastoreException` if an exception is reported by the datastore

setLimits(long, long)

```
public abstract void setLimits(
  long skip,
  long limit);
```

Set limits on results to return. The execution of the query is modified to return only a subset of results. If the filter would normally return 100 instances, skip is set to 50, and limit is set to 40, then the first 50 results that would have been returned are skipped, the next 40 results are returned and the remaining 10 results are ignored.

Skip must be greater than or equal to 0. Limit must be greater than or equal to 0. Limits may not be used with deletePersistentAll.

Table 4.41 setLimits(long, long)

Parameter	Description
skip	the number of results to skip
limit	the number of results to return after skipping; use Long.MAX_VALUE for no limit.

setOrdering(Query.Ordering, String...)

```
public abstract void setOrdering(
  Ordering ordering,
  String[] orderingFields);
```

Set ordering for the results of this query. The execution of the query is modified to use an index previously defined.

- There must be an index defined on the columns mapped to the ordering fields, in the order of the ordering fields.
- There must be no gaps in the ordering fields relative to the index.
- All ordering fields must be in the index, but not all fields in the index need be in the ordering fields.
- If an "in" predicate is used in the filter on a field in the ordering, it can only be used with the first field.
- If any of these conditions is violated, ClusterJUserException is thrown when the query is executed.

If an "in" predicate is used, each element in the parameter defines a separate range, and ordering is performed within that range. There may be a better (more efficient) index based on the filter, but specifying the ordering will force the query to use an index that contains the ordering fields.

Table 4.42 setOrdering(Query.Ordering, String...)

Parameter	Description
ordering	either Ordering.ASCENDING or Ordering.DESCENDING
orderingFields	the fields to order by

setParameter(String, Object)

```
public abstract void setParameter(
  String parameterName,
  Object value);
```

Set the value of a parameter. If called multiple times for the same parameter, silently replace the value.

Table 4.43 setParameter(String, Object)

Parameter	Description
parameterName	the name of the parameter
value	the value for the parameter

4.3.1.18 Query.Ordering

Ordering

Synopsis

```
public static final class Query.Ordering,
```

```
  extends  Enum<Ordering> {
// Public Static Fields

  public static final Ordering
    ASCENDING ;

  public static final Ordering
    DESCENDING ;

// Public Static Methods

  public static Ordering valueOf(
    String name);

  public static Ordering[] values();

}
```

Methods inherited from java.lang.Enum: `compareTo` , `equals` , `getDeclaringClass` , `hashCode` , `name` , `ordinal` , `toString` , `valueOf`

Methods inherited from java.lang.Object: `getClass` , `notify` , `notifyAll` , `wait`

4.3.1.19 Results

Results of a query.

Synopsis

```
public interface Results<E>,
  extends  Iterable<E> {
// Public Methods

  public abstract Iterator<E> iterator();

}
```

iterator()

```
  public abstract Iterator<E> iterator();
```

Specified by: Method `iterator` in interface `Iterable`

Get an iterator over the results of a query.

Table 4.44 iterator()

Parameter	Description
return	the iterator

4.3.1.20 Session

Session is the primary user interface to the cluster. Session extends AutoCloseable so it can be used in the try-with-resources pattern. This pattern allows the application to create a session in the try declaration and regardless of the outcome of the try/catch/finally block, clusterj will clean up and close the session. If the try block exits with an open transaction, the transaction will be rolled back before the session is closed.

Synopsis

```
public interface Session,
  extends  AutoCloseable {
// Public Methods

  public abstract void close();

  public abstract Query<T> createQuery(
```

```
    QueryDefinition<T> qd);

  public abstract Transaction currentTransaction();

  public abstract void deletePersistent(
    Class<T> cls,
    Object key);

  public abstract void deletePersistent(
    Object instance);

  public abstract int deletePersistentAll(
    Class<T> cls);

  public abstract void deletePersistentAll(
    Iterable<?> instances);

  public abstract T find(
    Class<T> cls,
    Object key);

  public abstract void flush();

  public abstract Boolean found(
    Object instance);

  public abstract QueryBuilder getQueryBuilder();

  public abstract boolean isClosed();

  public abstract T load(
    T instance);

  public abstract T makePersistent(
    T instance);

  public abstract Iterable<?> makePersistentAll(
    Iterable<?> instances);

  public abstract void markModified(
    Object instance,
    String fieldName);

  public abstract T newInstance(
    Class<T> cls);

  public abstract T newInstance(
    Class<T> cls,
    Object key);

  public abstract void persist(
    Object instance);

  public abstract T release(
    T obj);

  public abstract void remove(
    Object instance);

  public abstract T savePersistent(
    T instance);

  public abstract Iterable<?> savePersistentAll(
    Iterable<?> instances);

  public abstract void setLockMode(
    LockMode lockmode);

  public abstract void setPartitionKey(
    Class<?> cls,
    Object key);
```

```
  public abstract String unloadSchema(
    Class<?> cls);

  public abstract void updatePersistent(
    Object instance);

  public abstract void updatePersistentAll(
    Iterable<?> instances);

}
```

close()

```
  public abstract void close();
```

Specified by: Method `close` in interface `AutoCloseable`

Close this session.

createQuery(QueryDefinition<T>)

```
  public abstract Query<T> createQuery(
    QueryDefinition<T> qd);
```

Create a Query from a QueryDefinition.

Table 4.45 createQuery(QueryDefinition<T>)

Parameter	Description
qd	the query definition
return	the query instance

currentTransaction()

```
  public abstract Transaction currentTransaction();
```

Get the current `com.mysql.clusterj.Transaction`.

Table 4.46 currentTransaction()

Parameter	Description
return	the transaction

deletePersistent(Class<T>, Object)

```
  public abstract void deletePersistent(
    Class<T> cls,
    Object key);
```

Delete an instance of a class from the database given its primary key. For single-column keys, the key parameter is a wrapper (e.g. Integer). For multi-column keys, the key parameter is an Object[] in which elements correspond to the primary keys in order as defined in the schema.

Table 4.47 deletePersistent(Class<T>, Object)

Parameter	Description
cls	the interface or dynamic class
key	the primary key

deletePersistent(Object)

```
  public abstract void deletePersistent(
```

```
    Object instance);
```

Delete the instance from the database. Only the id field is used to determine which instance is to be deleted. If the instance does not exist in the database, an exception is thrown.

Table 4.48 deletePersistent(Object)

Parameter	Description
instance	the instance to delete

deletePersistentAll(Class<T>)

```
public abstract int deletePersistentAll(
    Class<T> cls);
```

Delete all instances of this class from the database. No exception is thrown even if there are no instances in the database.

Table 4.49 deletePersistentAll(Class<T>)

Parameter	Description
cls	the interface or dynamic class
return	the number of instances deleted

deletePersistentAll(Iterable<?>)

```
public abstract void deletePersistentAll(
    Iterable<?> instances);
```

Delete all parameter instances from the database.

Table 4.50 deletePersistentAll(Iterable<?>)

Parameter	Description
instances	the instances to delete

find(Class<T>, Object)

```
public abstract T find(
    Class<T> cls,
    Object key);
```

Find a specific instance by its primary key. The key must be of the same type as the primary key defined by the table corresponding to the cls parameter. The key parameter is the wrapped version of the primitive type of the key, e.g. Integer for INT key types, Long for BIGINT key types, or String for char and varchar types. For multi-column primary keys, the key parameter is an Object[], each element of which is a component of the primary key. The elements must be in the order of declaration of the columns (not necessarily the order defined in the CONSTRAINT ... PRIMARY KEY clause) of the CREATE TABLE statement.

Table 4.51 find(Class<T>, Object)

Parameter	Description
cls	the interface or dynamic class to find an instance of
key	the key of the instance to find
return	the instance of the interface or dynamic class with the specified key

flush()

```
public abstract void flush();
```

Flush deferred changes to the back end. Inserts, deletes, loads, and updates are sent to the back end.

found(Object)

```
public abstract Boolean found(
  Object instance);
```

Was the row corresponding to this instance found in the database?

Table 4.52 found(Object)

Parameter	Description
instance	the instance corresponding to the row in the database
return	• null if the instance is null or was created via newInstance and never loaded; • true if the instance was returned from a find or query or created via newInstance and successfully loaded; • false if the instance was created via newInstance and not found.

See Also load(T) , newInstance(java.lang.Class<T>, java.lang.Object)

getQueryBuilder()

```
public abstract QueryBuilder getQueryBuilder();
```

Get a QueryBuilder.

Table 4.53 getQueryBuilder()

Parameter	Description
return	the query builder

isClosed()

```
public abstract boolean isClosed();
```

Is this session closed?

Table 4.54 isClosed()

Parameter	Description
return	true if the session is closed

load(T)

```
public abstract T load(
  T instance);
```

Load the instance from the database into memory. Loading is asynchronous and will be executed when an operation requiring database access is executed: find, flush, or query. The instance must have been returned from find or query; or created via session.newInstance and its primary key initialized.

Table 4.55 load(T)

Parameter	Description
instance	the instance to load
return	the instance

See Also found(java.lang.Object)

makePersistent(T)

```
public abstract T makePersistent(
  T instance);
```

Insert the instance into the database. If the instance already exists in the database, an exception is thrown.

Table 4.56 makePersistent(T)

Parameter	Description
instance	the instance to insert
return	the instance

See Also savePersistent(T)

makePersistentAll(Iterable<?>)

```
public abstract Iterable<?> makePersistentAll(
  Iterable<?> instances);
```

Insert the instances into the database.

Table 4.57 makePersistentAll(Iterable<?>)

Parameter	Description
instances	the instances to insert.
return	the instances

markModified(Object, String)

```
public abstract void markModified(
  Object instance,
  String fieldName);
```

Mark the field in the object as modified so it is flushed.

Table 4.58 markModified(Object, String)

Parameter	Description
instance	the persistent instance
fieldName	the field to mark as modified

newInstance(Class<T>)

```
public abstract T newInstance(
  Class<T> cls);
```

Create an instance of an interface or dynamic class that maps to a table.

Table 4.59 newInstance(Class<T>)

Parameter	Description
cls	the interface for which to create an instance
return	an instance that implements the interface

newInstance(Class<T>, Object)

```
public abstract T newInstance(
  Class<T> cls,
  Object key);
```

Create an instance of an interface or dynamic class that maps to a table and set the primary key of the new instance. The new instance can be used to create, delete, or update a record in the database.

Table 4.60 newInstance(Class<T>, Object)

Parameter	Description
cls	the interface for which to create an instance
return	an instance that implements the interface

persist(Object)

```
public abstract void persist(
  Object instance);
```

Insert the instance into the database. This method has identical semantics to makePersistent.

Table 4.61 persist(Object)

Parameter	Description
instance	the instance to insert

release(T)

```
public abstract T release(
  T obj);
```

Release resources associated with an instance. The instance must be a domain object obtained via session.newInstance(T.class), find(T.class), or query; or Iterable, or array T[]. Resources released can include direct buffers used to hold instance data. Released resources may be returned to a pool.

Table 4.62 release(T)

Parameter	Description
obj	a domain object of type T, an Iterable, or array T[]
return	the input parameter

Exceptions

`ClusterJUserException`	if the instance is not a domain object T, Iterable, or array T[], or if the object is used after calling this method.

remove(Object)

```
public abstract void remove(
  Object instance);
```

Delete the instance from the database. This method has identical semantics to deletePersistent.

Table 4.63 remove(Object)

Parameter	Description
instance	the instance to delete

savePersistent(T)

```
public abstract T savePersistent(
  T instance);
```

Save the instance in the database without checking for existence. The id field is used to determine which instance is to be saved. If the instance exists in the database it will be updated. If the instance does not exist, it will be created.

Table 4.64 savePersistent(T)

Parameter	Description
instance	the instance to update

savePersistentAll(Iterable<?>)

```
public abstract Iterable<?> savePersistentAll(
  Iterable<?> instances);
```

Update all parameter instances in the database.

Table 4.65 savePersistentAll(Iterable<?>)

Parameter	Description
instances	the instances to update

setLockMode(LockMode)

```
public abstract void setLockMode(
  LockMode lockmode);
```

Set the lock mode for read operations. This will take effect immediately and will remain in effect until this session is closed or this method is called again.

Table 4.66 setLockMode(LockMode)

Parameter	Description
lockmode	the LockMode

setPartitionKey(Class<?>, Object)

```
public abstract void setPartitionKey(
  Class<?> cls,
  Object key);
```

Set the partition key for the next transaction. The key must be of the same type as the primary key defined by the table corresponding to the cls parameter. The key parameter is the wrapped version of the primitive type of the key, e.g. Integer for INT key types, Long for BIGINT key types, or String for char and varchar types. For multi-column primary keys, the key parameter is an Object[], each element of which is a component of the primary key. The elements must be in the order of declaration of the columns (not necessarily the order defined in the CONSTRAINT ... PRIMARY KEY clause) of the CREATE TABLE statement.

Table 4.67 setPartitionKey(Class<?>, Object)

Parameter	Description
key	the primary key of the mapped table

Exceptions

`ClusterJUserException`	if a transaction is enlisted
`ClusterJUserException`	if a partition key is null
`ClusterJUserException`	if called twice in the same transaction
`ClusterJUserException`	if a partition key is the wrong type

unloadSchema(Class<?>)

```
public abstract String unloadSchema(
  Class<?> cls);
```

Unload the schema definition for a class. This must be done after the schema definition has changed in the database due to an alter table command. The next time the class is used the schema will be reloaded.

Table 4.68 unloadSchema(Class<?>)

Parameter	Description
cls	the class for which the schema is unloaded
return	the name of the schema that was unloaded

updatePersistent(Object)

```
public abstract void updatePersistent(
  Object instance);
```

Update the instance in the database without necessarily retrieving it. The id field is used to determine which instance is to be updated. If the instance does not exist in the database, an exception is thrown. This method cannot be used to change the primary key.

Table 4.69 updatePersistent(Object)

Parameter	Description
instance	the instance to update

updatePersistentAll(Iterable<?>)

```
public abstract void updatePersistentAll(
  Iterable<?> instances);
```

Update all parameter instances in the database.

Table 4.70 updatePersistentAll(Iterable<?>)

Parameter	Description
instances	the instances to update

4.3.1.21 SessionFactory

SessionFactory represents a cluster.

Synopsis

```
public interface SessionFactory {
// Public Methods

  public abstract void close();

  public abstract State currentState();

  public abstract List<Integer> getConnectionPoolSessionCounts();

  public abstract int getRecvThreadActivationThreshold();

  public abstract short[] getRecvThreadCPUids();

  public abstract Session getSession();

  public abstract Session getSession(
    Map properties);

  public abstract void reconnect();

  public abstract void reconnect(
    int timeout);
```

```
public abstract void setRecvThreadActivationThreshold(
    int threshold);

  public abstract void setRecvThreadCPUids(
    short[] cpuids);

}
```

close()

```
public abstract void close();
```

Close this session factory. Release all resources. Set the current state to Closed. When closed, calls to getSession will throw ClusterJUserException.

currentState()

```
public abstract State currentState();
```

Get the current state of this session factory.

Since	7.5.7
See Also	com.mysql.clusterj.SessionFactory.State

getConnectionPoolSessionCounts()

```
public abstract List<Integer> getConnectionPoolSessionCounts();
```

Get a list containing the number of open sessions for each connection in the connection pool.

Since	7.3.14, 7.4.12, 7.5.2

getRecvThreadActivationThreshold()

```
public abstract int getRecvThreadActivationThreshold();
```

Get the receive thread activation threshold for all connections in the connection pool. 16 or higher means that receive threads are never used as receivers. 0 means that the receive thread is always active, and that retains poll rights for its own exclusive use, effectively blocking all user threads from becoming receivers. In such cases care should be taken to ensure that the receive thread does not compete with the user thread for CPU resources; it is preferable for it to be locked to a CPU for its own exclusive use. The default is 8.

Since	7.5.7

getRecvThreadCPUids()

```
public abstract short[] getRecvThreadCPUids();
```

Get receive thread bindings to cpus for all connections in the connection pool. If a receive thread is not bound to a cpu, the corresponding value will be -1.

Since	7.5.7

getSession()

```
public abstract Session getSession();
```

Create a Session to use with the cluster, using all the properties of the SessionFactory.

Table 4.71 getSession()

Parameter	Description
return	the session

getSession(Map)

```
public abstract Session getSession(
  Map properties);
```

Create a session to use with the cluster, overriding some properties. Properties PROPERTY_CLUSTER_CONNECTSTRING, PROPERTY_CLUSTER_DATABASE, and PROPERTY_CLUSTER_MAX_TRANSACTIONS may not be overridden.

Table 4.72 getSession(Map)

Parameter	Description
properties	overriding some properties for this session
return	the session

reconnect()

```
public abstract void reconnect();
```

Reconnect this session factory using the most recent timeout value specified. The timeout may have been specified in the original session factory properties or may have been changed by an application call to reconnect(int timeout).

See Also reconnect(int)

Since 7.5.7

reconnect(int)

```
public abstract void reconnect(
  int timeout);
```

Disconnect and reconnect this session factory using the specified timeout value and change the saved timeout value. This is a heavyweight method and should be used rarely. It is intended for cases where the process in which clusterj is running has lost connectivity to the cluster and is not able to function normally. Reconnection is done in several phases. First, the session factory is set to state Reconnecting and a reconnect thread is started to manage the reconnection procedure. In the Reconnecting state, the getSession methods throw ClusterJUserException and the connection pool is quiesced until all sessions have closed. If sessions fail to close normally after timeout seconds, the sessions are forced to close. Next, all connections in the connection pool are closed, which frees their connection slots in the cluster. Finally, the connection pool is recreated using the original connection pool properties and the state is set to Open. The reconnection procedure is asynchronous. To observe the progress of the procedure, use the methods currentState and getConnectionPoolSessionCounts. If the timeout value is non-zero, automatic reconnection will be done by the clusterj implementation upon recognizing that a network failure has occurred. If the timeout value is 0, automatic reconnection is disabled. If the current state of this session factory is Reconnecting, this method silently does nothing.

Table 4.73 reconnect(int)

Parameter	Description
timeout	the timeout value in seconds; 0 to disable automatic reconnection

Since 7.5.7

setRecvThreadActivationThreshold(int)

```
public abstract void setRecvThreadActivationThreshold(
  int threshold);
```

Set the receive thread activation threshold for all connections in the connection pool. 16 or higher means that receive threads are never used as receivers. 0 means that the receive thread is always active, and that retains poll rights for its own exclusive use, effectively blocking all user threads from becoming receivers. In such cases care should be taken to ensure that the receive thread does not compete with the user thread for CPU resources; it is preferable for it to be locked to a CPU for its own exclusive use. The default is 8.

Exceptions

`ClusterJUserException`	if the value is negative
`ClusterJFatalInternalException`	if the method fails due to some internal reason.
Since	7.5.7

setRecvThreadCPUids(short[])

```
public abstract void setRecvThreadCPUids(
  short[] cpuids);
```

Bind receive threads to cpuids for all connections in the connection pool. Specify -1 to unset receive thread cpu binding for a connection. The cpuid must be between 0 and the number of cpus in the machine.

Exceptions

`ClusterJUserException`	if the cpuid is illegal or if the number of elements in cpuids is not equal to the number of connections in the connection pool.
`ClusterJFatalInternalException`	if the binding fails due to some internal reason.
Since	7.5.7

4.3.1.22 SessionFactory.State

State of this session factory

Synopsis

```
public static final class SessionFactory.State,
  extends  Enum<State> {
// Public Static Fields

  public static final State
    Closed ;

  public static final State
    Open ;

  public static final State
    Reconnecting ;

// Public Static Methods

  public static State valueOf(
    String name);

  public static State[] values();

}
```

Methods inherited from java.lang.Enum: `compareTo` , `equals` , `getDeclaringClass` , `hashCode` , `name` , `ordinal` , `toString` , `valueOf`

Methods inherited from java.lang.Object: `getClass` , `notify` , `notifyAll` , `wait`

Since	7.5.7

4.3.1.23 SessionFactoryService

This interface defines the service to create a SessionFactory from a Map<String, String> of properties.

Synopsis

```
public interface SessionFactoryService {
// Public Methods

  public abstract SessionFactory getSessionFactory(
    Map<String, String> props);

}
```

getSessionFactory(Map<String, String>)

```
  public abstract SessionFactory getSessionFactory(
    Map<String, String> props);
```

Create or get a session factory. If a session factory with the same value for PROPERTY_CLUSTER_CONNECTSTRING has already been created in the VM, the existing factory is returned, regardless of whether other properties of the factory are the same as specified in the Map.

Table 4.74 getSessionFactory(Map<String, String>)

Parameter	Description
props	the properties for the session factory, in which the keys are defined in Constants and the values describe the environment
return	the session factory

See Also com.mysql.clusterj.Constants

4.3.1.24 Transaction

Transaction represents a user transaction active in the cluster.

Synopsis

```
public interface Transaction {
// Public Methods

  public abstract void begin();

  public abstract void commit();

  public abstract boolean getRollbackOnly();

  public abstract boolean isActive();

  public abstract void rollback();

  public abstract void setRollbackOnly();

}
```

begin()

```
  public abstract void begin();
```

Begin a transaction.

commit()

```
  public abstract void commit();
```

Commit a transaction.

getRollbackOnly()

```
public abstract boolean getRollbackOnly();
```

Has this transaction been marked for rollback only?

Table 4.75 getRollbackOnly()

Parameter	Description
return	true if the transaction has been marked for rollback only

isActive()

```
public abstract boolean isActive();
```

Is there a transaction currently active?

Table 4.76 isActive()

Parameter	Description
return	true if a transaction is active

rollback()

```
public abstract void rollback();
```

Roll back a transaction.

setRollbackOnly()

```
public abstract void setRollbackOnly();
```

Mark this transaction as rollback only. After this method is called, commit() will roll back the transaction and throw an exception; rollback() will roll back the transaction and not throw an exception.

4.3.2 com.mysql.clusterj.annotation

This package provides annotations for domain object model interfaces mapped to database tables.

4.3.2.1 Column

Annotation for a column in the database.

Synopsis

```
@Target(value={java.lang.annotation.ElementType.FIELD, java.lang.annotation.ElementType.METHOD}) @Reten

  public String
    name ;

  public String
    allowsNull ;

  public String
    defaultValue ;

}
```

allowsNull

Whether the column allows null values to be inserted. This overrides the database definition and requires that the application provide non-null values for the database column.

Table 4.77 allowsNull

Parameter	Description
return	whether the column allows null values to be inserted

defaultValue

Default value for this column.

Table 4.78 defaultValue

Parameter	Description
return	the default value for this column

name

Name of the column.

Table 4.79 name

Parameter	Description
return	the name of the column

4.3.2.2 Columns

Annotation for a group of columns. This annotation is used for multi-column structures such as indexes and keys.

Synopsis

```
@Target(value={java.lang.annotation.ElementType.FIELD, java.lang.annotation.ElementType.METHOD, java.lang.a

  public Column[]
    value ;

}
```

value

The columns annotation information.

Table 4.80 value

Parameter	Description
return	the columns

4.3.2.3 Extension

Annotation for a non-standard extension.

Synopsis

```
@Target(value={java.lang.annotation.ElementType.TYPE, java.lang.annotation.ElementType.FIELD, java.lang.ann

  public String
    vendorName ;

  public String
    key ;

  public String
    value ;
```

```
}
```

key

The key for the extension (required).

Table 4.81 key

Parameter	Description
return	the key

value

The value for the extension (required).

Table 4.82 value

Parameter	Description
return	the value

vendorName

Vendor that the extension applies to (required to make the key unique).

Table 4.83 vendorName

Parameter	Description
return	the vendor

4.3.2.4 Extensions

Annotation for a group of extensions.

Synopsis

```
@Target(value={java.lang.annotation.ElementType.TYPE, java.lang.annotation.ElementType.FIELD, java.lang

  public Extension[]
    value ;

}
```

value

The extensions.

Table 4.84 value

Parameter	Description
return	the extensions

4.3.2.5 Index

Annotation for a database index.

Synopsis

```
@Target(value={java.lang.annotation.ElementType.TYPE, java.lang.annotation.ElementType.FIELD, java.lang

  public String
    name ;
```

```
  public String
    unique ;

  public Column[]
    columns ;

}
```

columns

Columns that compose this index.

Table 4.85 columns

Parameter	Description
return	columns that compose this index

name

Name of the index

Table 4.86 name

Parameter	Description
return	the name of the index

unique

Whether this index is unique

Table 4.87 unique

Parameter	Description
return	whether this index is unique

4.3.2.6 Indices

Annotation for a group of indices. This is used on a class where there are multiple indices defined.

Synopsis

```
@Target(value=java.lang.annotation.ElementType.TYPE) @Retention(value=java.lang.annotation.RetentionPolicy.

  public Index[]
    value ;

}
```

value

The indices.

Table 4.88 value

Parameter	Description
return	The indices

4.3.2.7 Lob

Annotation for a Large Object (lob). This annotation can be used with byte[] and InputStream types for binary columns; and with String and InputStream types for character columns.

Synopsis

```
@Target(value={java.lang.annotation.ElementType.FIELD, java.lang.annotation.ElementType.METHOD}) @Reten
}
```

4.3.2.8 NotPersistent

Annotation to specify that the member is not persistent. If used, this is the only annotation allowed on a member.

Synopsis

```
@Target(value={java.lang.annotation.ElementType.FIELD, java.lang.annotation.ElementType.METHOD}) @Reten
}
```

4.3.2.9 NullValue

Enumeration of the "null-value" behavior values. This behavior is specified in the @Persistent annotation.

Synopsis

```
public final class NullValue,
  extends  Enum<NullValue> {
// Public Static Fields

  public static final NullValue
    DEFAULT ;

  public static final NullValue
    EXCEPTION ;

  public static final NullValue
    NONE ;

// Public Static Methods

  public static NullValue valueOf(
    String name);

  public static NullValue[] values();

}
```

Methods inherited from java.lang.Enum: `compareTo` , `equals` , `getDeclaringClass` , `hashCode` , `name` , `ordinal` , `toString` , `valueOf`

Methods inherited from java.lang.Object: `getClass` , `notify` , `notifyAll` , `wait`

4.3.2.10 PartitionKey

Annotation on a class or member to define the partition key. If annotating a class or interface, either a single column or multiple columns can be specified. If annotating a member, neither column nor columns should be specified.

Synopsis

```
@Target(value={java.lang.annotation.ElementType.TYPE, java.lang.annotation.ElementType.FIELD, java.lang

  public String
    column ;

  public Column[]
    columns ;

}
```

column

Name of the column to use for the partition key

Table 4.89 column

Parameter	Description
return	the name of the column to use for the partition key

columns

The column(s) for the partition key

Table 4.90 columns

Parameter	Description
return	the column(s) for the partition key

4.3.2.11 PersistenceCapable

Annotation for whether the class or interface is persistence-capable.

Synopsis

```
@Target(value=java.lang.annotation.ElementType.TYPE) @Retention(value=java.lang.annotation.RetentionPolicy.

  public String
    table ;

  public String
    database ;

  public String
    schema ;

}
```

4.3.2.12 PersistenceModifier

Enumeration of the persistence-modifier values for a member.

Synopsis

```
public final class PersistenceModifier,
  extends  Enum<PersistenceModifier> {
// Public Static Fields

  public static final PersistenceModifier
    NONE ;

  public static final PersistenceModifier
    PERSISTENT ;

  public static final PersistenceModifier
    UNSPECIFIED ;

// Public Static Methods

  public static PersistenceModifier valueOf(
    String name);

  public static PersistenceModifier[] values();

}
```

Methods inherited from java.lang.Enum: `compareTo` , `equals` , `getDeclaringClass` , `hashCode` , `name` , `ordinal` , `toString` , `valueOf`

Methods inherited from java.lang.Object: `getClass` , `notify` , `notifyAll` , `wait`

4.3.2.13 Persistent

Annotation for defining the persistence of a member.

Synopsis

```
@Target(value={java.lang.annotation.ElementType.FIELD, java.lang.annotation.ElementType.METHOD}) @Reten

  public NullValue
    nullValue ;

  public String
    primaryKey ;

  public String
    column ;

  public Extension[]
    extensions ;

}
```

column

Column name where the values are stored for this member.

Table 4.91 column

Parameter	Description
return	the name of the column

extensions

Non-standard extensions for this member.

Table 4.92 extensions

Parameter	Description
return	the non-standard extensions

nullValue

Behavior when this member contains a null value.

Table 4.93 nullValue

Parameter	Description
return	the behavior when this member contains a null value

primaryKey

Whether this member is part of the primary key for the table. This is equivalent to specifying @PrimaryKey as a separate annotation on the member.

Table 4.94 primaryKey

Parameter	Description
return	whether this member is part of the primary key

4.3.2.14 PrimaryKey

Annotation on a member to define it as a primary key member of a class or persistent interface.

Synopsis

```
@Target(value={java.lang.annotation.ElementType.TYPE, java.lang.annotation.ElementType.FIELD, java.lang.ann

  public String
    name ;

  public String
    column ;

  public Column[]
    columns ;

}
```

column

Name of the column to use for the primary key

Table 4.95 column

Parameter	Description
return	the name of the column to use for the primary key

columns

The column(s) for the primary key

Table 4.96 columns

Parameter	Description
return	the column(s) for the primary key

name

Name of the primary key constraint

Table 4.97 name

Parameter	Description
return	the name of the primary key constraint

4.3.2.15 Projection

Annotation on a type to define it as a projection of a table. Only the columns mapped to persistent fields/methods will be used when performing operations on the table.

Synopsis

```
@Target(value=java.lang.annotation.ElementType.TYPE) @Retention(value=java.lang.annotation.RetentionPolicy.
}
```

4.3.3 com.mysql.clusterj.query

Provides interfaces for building queries for ClusterJ.

4.3.3.1 Predicate

Used to combine multiple predicates with boolean operations.

Synopsis

```
public interface Predicate {
// Public Methods

  public abstract Predicate and(
    Predicate predicate);

  public abstract Predicate not();

  public abstract Predicate or(
    Predicate predicate);

}
```

and(Predicate)

```
  public abstract Predicate and(
    Predicate predicate);
```

Combine this Predicate with another, using the "and" semantic.

Table 4.98 and(Predicate)

Parameter	Description
predicate	the other predicate
return	a new Predicate combining both Predicates

not()

```
  public abstract Predicate not();
```

Negate this Predicate.

Table 4.99 not()

Parameter	Description
return	this predicate

or(Predicate)

```
  public abstract Predicate or(
    Predicate predicate);
```

Combine this Predicate with another, using the "or" semantic.

Table 4.100 or(Predicate)

Parameter	Description
predicate	the other predicate
return	a new Predicate combining both Predicates

4.3.3.2 PredicateOperand

PredicateOperand represents a column or parameter that can be compared to another

Synopsis

```
public interface PredicateOperand {
// Public Methods

  public abstract Predicate between(
```

```
    PredicateOperand lower,
    PredicateOperand upper);

  public abstract Predicate equal(
    PredicateOperand other);

  public abstract Predicate greaterEqual(
    PredicateOperand other);

  public abstract Predicate greaterThan(
    PredicateOperand other);

  public abstract Predicate in(
    PredicateOperand other);

  public abstract Predicate isNotNull();

  public abstract Predicate isNull();

  public abstract Predicate lessEqual(
    PredicateOperand other);

  public abstract Predicate lessThan(
    PredicateOperand other);

  public abstract Predicate like(
    PredicateOperand other);

}
```

between(PredicateOperand, PredicateOperand)

```
  public abstract Predicate between(
    PredicateOperand lower,
    PredicateOperand upper);
```

Return a Predicate representing comparing this to another using "between" semantics.

Table 4.101 between(PredicateOperand, PredicateOperand)

Parameter	Description
lower	another PredicateOperand
upper	another PredicateOperand
return	a new Predicate

equal(PredicateOperand)

```
  public abstract Predicate equal(
    PredicateOperand other);
```

Return a Predicate representing comparing this to another using "equal to" semantics.

Table 4.102 equal(PredicateOperand)

Parameter	Description
other	the other PredicateOperand
return	a new Predicate

greaterEqual(PredicateOperand)

```
  public abstract Predicate greaterEqual(
    PredicateOperand other);
```

Return a Predicate representing comparing this to another using "greater than or equal to" semantics.

Table 4.103 greaterEqual(PredicateOperand)

Parameter	Description
other	the other PredicateOperand
return	a new Predicate

greaterThan(PredicateOperand)

```
public abstract Predicate greaterThan(
  PredicateOperand other);
```

Return a Predicate representing comparing this to another using "greater than" semantics.

Table 4.104 greaterThan(PredicateOperand)

Parameter	Description
other	the other PredicateOperand
return	a new Predicate

in(PredicateOperand)

```
public abstract Predicate in(
  PredicateOperand other);
```

Return a Predicate representing comparing this to a collection of values using "in" semantics.

Table 4.105 in(PredicateOperand)

Parameter	Description
other	another PredicateOperand
return	a new Predicate

isNotNull()

```
public abstract Predicate isNotNull();
```

Return a Predicate representing comparing this to not null.

Table 4.106 isNotNull()

Parameter	Description
return	a new Predicate

isNull()

```
public abstract Predicate isNull();
```

Return a Predicate representing comparing this to null.

Table 4.107 isNull()

Parameter	Description
return	a new Predicate

lessEqual(PredicateOperand)

```
public abstract Predicate lessEqual(
  PredicateOperand other);
```

Return a Predicate representing comparing this to another using "less than or equal to" semantics.

Table 4.108 lessEqual(PredicateOperand)

Parameter	Description
other	the other PredicateOperand
return	a new Predicate

lessThan(PredicateOperand)

```
public abstract Predicate lessThan(
  PredicateOperand other);
```

Return a Predicate representing comparing this to another using "less than" semantics.

Table 4.109 lessThan(PredicateOperand)

Parameter	Description
other	the other PredicateOperand
return	a new Predicate

like(PredicateOperand)

```
public abstract Predicate like(
  PredicateOperand other);
```

Return a Predicate representing comparing this to another using "like" semantics.

Table 4.110 like(PredicateOperand)

Parameter	Description
other	another PredicateOperand
return	a new Predicate

4.3.3.3 QueryBuilder

QueryBuilder represents a factory for queries.

Synopsis

```
public interface QueryBuilder {
// Public Methods

  public abstract QueryDomainType<T> createQueryDefinition(
    Class<T> cls);

}
```

See Also getQueryBuilder()

createQueryDefinition(Class<T>)

```
public abstract QueryDomainType<T> createQueryDefinition(
  Class<T> cls);
```

Create a QueryDefinition to define queries.

Table 4.111 createQueryDefinition(Class<T>)

Parameter	Description
cls	the class of the type to be queried
return	the QueryDomainType to define the query

4.3.3.4 QueryDefinition

QueryDefinition allows users to define queries.

Synopsis

```
public interface QueryDefinition<E> {
// Public Methods

  public abstract Predicate not(
    Predicate predicate);

  public abstract PredicateOperand param(
    String parameterName);

  public abstract QueryDefinition<E> where(
    Predicate predicate);

}
```

not(Predicate)

```
  public abstract Predicate not(
    Predicate predicate);
```

Convenience method to negate a predicate.

Table 4.112 not(Predicate)

Parameter	Description
predicate	the predicate to negate
return	the inverted predicate

param(String)

```
  public abstract PredicateOperand param(
    String parameterName);
```

Specify a parameter for the query.

Table 4.113 param(String)

Parameter	Description
parameterName	the name of the parameter
return	the PredicateOperand representing the parameter

where(Predicate)

```
  public abstract QueryDefinition<E> where(
    Predicate predicate);
```

Specify the predicate to satisfy the query.

Table 4.114 where(Predicate)

Parameter	Description
predicate	the Predicate
return	this query definition

4.3.3.5 QueryDomainType

QueryDomainType represents the domain type of a query. The domain type validates property names that are used to filter results.

Synopsis

```
public interface QueryDomainType<E>,
  extends  QueryDefinition<E> {
// Public Methods

  public abstract PredicateOperand get(
    String propertyName);

  public abstract Class<E> getType();

}
```

get(String)

```
  public abstract PredicateOperand get(
    String propertyName);
```

Get a PredicateOperand representing a property of the domain type.

Table 4.115 get(String)

Parameter	Description
propertyName	the name of the property
return	a representation the value of the property

getType()

```
  public abstract Class<E> getType();
```

Get the domain type of the query.

Table 4.116 getType()

Parameter	Description
return	the domain type of the query

4.3.4 Constant field values

4.3.4.1 com.mysql.clusterj.*

Table 4.117 com.mysql.clusterj.*

Name	Description
DEFAULT_PROPERTY_CLUSTER_BYTE_BUFFER_POOL_SIZES	"256, 10240, 102400, 1048576"
DEFAULT_PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_BATCH_SIZE	10
DEFAULT_PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_START	1
DEFAULT_PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_STEP	1
DEFAULT_PROPERTY_CLUSTER_CONNECT_DELAY	5
DEFAULT_PROPERTY_CLUSTER_CONNECT_RETRIES	4
DEFAULT_PROPERTY_CLUSTER_CONNECT_TIMEOUT_AFTER	20
DEFAULT_PROPERTY_CLUSTER_CONNECT_TIMEOUT_BEFORE	30
DEFAULT_PROPERTY_CLUSTER_CONNECT_TIMEOUT_MGM	30000
DEFAULT_PROPERTY_CLUSTER_CONNECT_VERBOSE	0
DEFAULT_PROPERTY_CLUSTER_DATABASE	"test"
DEFAULT_PROPERTY_CLUSTER_MAX_TRANSACTIONS	4
DEFAULT_PROPERTY_CONNECTION_POOL_RECV_THREAD_ACTIVATION_THRESHOLD	8

Name	Description
DEFAULT_PROPERTY_CONNECTION_POOL_SIZE	1
DEFAULT_PROPERTY_CONNECTION_RECONNECT_TIMEOUT	0
ENV_CLUSTERJ_LOGGER_FACTORY_NAME	"CLUSTERJ_LOGGER_FACTORY"
PROPERTY_CLUSTER_BYTE_BUFFER_POOL_SIZES	"com.mysql.clusterj.byte.buffer.pool.sizes"
PROPERTY_CLUSTER_CONNECTION_SERVICE	"com.mysql.clusterj.connection.service"
PROPERTY_CLUSTER_CONNECTSTRING	"com.mysql.clusterj.connectstring"
PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_BATCH_SIZE	"com.mysql.clusterj.connect.autoincrement.batchsize"
PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_START	"com.mysql.clusterj.connect.autoincrement.offset"
PROPERTY_CLUSTER_CONNECT_AUTO_INCREMENT_STEP	"com.mysql.clusterj.connect.autoincrement.increment"
PROPERTY_CLUSTER_CONNECT_DELAY	"com.mysql.clusterj.connect.delay"
PROPERTY_CLUSTER_CONNECT_RETRIES	"com.mysql.clusterj.connect.retries"
PROPERTY_CLUSTER_CONNECT_TIMEOUT_AFTER	"com.mysql.clusterj.connect.timeout.after"
PROPERTY_CLUSTER_CONNECT_TIMEOUT_BEFORE	"com.mysql.clusterj.connect.timeout.before"
PROPERTY_CLUSTER_CONNECT_TIMEOUT_MGM	"com.mysql.clusterj.connect.timeout.mgm"
PROPERTY_CLUSTER_CONNECT_VERBOSE	"com.mysql.clusterj.connect.verbose"
PROPERTY_CLUSTER_DATABASE	"com.mysql.clusterj.database"
PROPERTY_CLUSTER_MAX_TRANSACTIONS	"com.mysql.clusterj.max.transactions"
PROPERTY_CONNECTION_POOL_NODEIDS	"com.mysql.clusterj.connection.pool.nodeids"
PROPERTY_CONNECTION_POOL_RECV_THREAD_ACTIVATION_THRESHOLD	"com.mysql.clusterj.connection.pool.recv.thread.activation.t
PROPERTY_CONNECTION_POOL_RECV_THREAD_CPUIDS	"com.mysql.clusterj.connection.pool.recv.thread.cpuids"
PROPERTY_CONNECTION_POOL_SIZE	"com.mysql.clusterj.connection.pool.size"
PROPERTY_CONNECTION_RECONNECT_TIMEOUT	"com.mysql.clusterj.connection.reconnect.timeout"
PROPERTY_DEFER_CHANGES	"com.mysql.clusterj.defer.changes"
PROPERTY_JDBC_DRIVER_NAME	"com.mysql.clusterj.jdbc.driver"
PROPERTY_JDBC_PASSWORD	"com.mysql.clusterj.jdbc.password"
PROPERTY_JDBC_URL	"com.mysql.clusterj.jdbc.url"
PROPERTY_JDBC_USERNAME	"com.mysql.clusterj.jdbc.username"
SESSION_FACTORY_SERVICE_CLASS_NAME	"com.mysql.clusterj.SessionFactoryService"
SESSION_FACTORY_SERVICE_FILE_NAME	"META-INF/services/ com.mysql.clusterj.SessionFactoryService"

Table 4.118 com.mysql.clusterj.*

Name	Description
INDEX_USED	"IndexUsed"
SCAN_TYPE	"ScanType"
SCAN_TYPE_INDEX_SCAN	"INDEX_SCAN"
SCAN_TYPE_PRIMARY_KEY	"PRIMARY_KEY"
SCAN_TYPE_TABLE_SCAN	"TABLE_SCAN"
SCAN_TYPE_UNIQUE_KEY	"UNIQUE_KEY"

4.4 MySQL NDB Cluster Connector for Java: Limitations and Known Issues

This section discusses the limitations and known issues in the MySQL NDB Cluster Connector for Java APIs.

Known issues in ClusterJ:

- *Joins:* With ClusterJ, queries are limited to single tables. This is not a problem with JPA or JDBC, both of which support joins.
- *Database views:* Because MySQL database views do not use the `NDB` storage engine, ClusterJ applications cannot "see" views, and thus cannot access them. To work with views using Java, you should use JPA or JDBC.
- *Relations and inheritance:* ClusterJ does not support relations or inheritance. Tables are mapped one-to-one onto domain classes, and only single-table operations are supported. `NDB` tables for NDB Cluster 7.3 and later support foreign keys, and foreign key constraints are enforced when using ClusterJ for inserts, updates, and deletes.
- *TIMESTAMP:* Currently, ClusterJ does not support the TIMESTAMP data type for a primary key field.

Known issues in JDBC and Connector/J: For information about limitations and known issues with JDBC and Connector/J, see JDBC API Implementation Notes, and Troubleshooting Connector/J Applications.

Known issues in NDB Cluster: For information about limitations and other known issues with NDB Cluster, see Known Limitations of NDB Cluster.

Chapter 5 MySQL NoSQL Connector for JavaScript

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This section provides information about the MySQL NoSQL Connector for JavaScript, a set of Node.js adapters for NDB Cluster and MySQL Server available beginning with NDB 7.3.1, which make it possible to write JavaScript applications for Node.js using MySQL data.

5.1 MySQL NoSQL Connector for JavaScript Overview

This connector differs in a number of key respects from most other MySQL Connectors and APIs. The interface is asynchronous, following the built-in Node.js event model. In addition, it employs a domain object model for data storage. Applications retrieve data in the form of fully-instantiated objects, rather than as rows and columns.

The MySQL Node.js adapter includes 2 drivers. The `ndb` driver accesses the `NDB` storage engine directly, using the NDB API (see Chapter 2, *The NDB API*). No MySQL Server is required for the `ndb` driver. The `mysql` driver uses a MySQL Server for its data source, and depends on the `node-mysql` Node.js module from https://github.com/felixge/node-mysql/. Regardless of the driver in use, no SQL statements are required; when using the Connector for JavaScript, Node.js applications employ data objects for all requests made to the database.

5.2 Installing the JavaScript Connector

This section covers basic installation and setup of the MySQL JavaScript Connector and its prerequites. The Connector requires both Node.js and NDB Cluster to be installed first; you can install these in either order. In addition, the `mysql-js` adapter requires the `node-mysql` driver. Building the Connector also requires that your system have a working C++ compiler such as `gcc` or Microsoft Visual Studio.

To install all of the prerequisites for the JavaScript Connector, including `node-mysql`, you should perform the following steps:

1. **Node.js.** If you do not already have Node.js installed on your system, you can obtain it from http://nodejs.org/download/. In addition to source code, prebuilt binaries and installers are available for a number of platforms. Many Linux distributions also have Node.js in their repositories (you may need to add an alternative repository in your package manager).

NDB 7.3.1 requires Node.js version 0.7.9 or earlier, due to dependency on `node-waf`. NDB 7.3.2 and later use `node-gyp` (see https://npmjs.org/package/node-gyp), and should work with Node.js 0.8.0 and later.

Regardless of the method by which you obtain Node.js, keep in mind that the architecture of the version you install must match that of the NDB Cluster binaries you intend to use; you cannot, for example, install the JavaScript Connector using 64-bit Node.js and 32-bit NDB Cluster. If you do not know the architecture of your existing Node.js installation, you can determine this by checking the value of `global.process.arch`.

2. **NDB Cluster.** If NDB Cluster, including all header and library files, is not already installed on the system, install it (see NDB Cluster Installation).

   As mentioned previously, you must make sure that the architecture (32-bit or 64-bit) is the same for both NDB Cluster and Node.js. You can check the architecture of an existing NDB Cluster installation in the output of `ndb_mgm -V`.

3. **node-mysql driver.** The `mysql-js` adapter also requires a working installation of the `node-mysql` driver from https://github.com/felixge/node-mysql/. You can install the driver using the Node.js `npm install` command; see the project website for the recommended version and package identifier.

Once the requirements just listed are met, you can find the files needed to install the MySQL Connector for JavaScript in `share/nodejs` in the NDB Cluster installation directory. (If you installed NDB Cluster as an RPM, this is `/usr/share/mysql/nodejs`.) To use the Node.js `npm` tool to perform a "best-guess" installation without any user intervention, change to the `share/nodejs` directory, then use `npm` as shown here:

```
shell> npm install .
```

The final period (`.`) character is required. Note that you must run this command in `share/node.js` in the NDB Cluster installation directory.

You can test your installation using the supplied test program. This requires a running NDB Cluster, including a MySQL Server with a database named `test`. The `mysql` client executable must be in the path.

To run the test suite, change to the `test` directory, then execute command shown here:

```
shell> node driver
```

By default, all servers are run on the local machine using default ports; this can be changed by editing the file `test/test_connection.js`, which is generated by running the test suite. If this file is not already present (see Bug #16967624), you can copy `share/nodejs/test/lib/test_connection_js` to the `test` directory for this purpose.

If you istalled NDB Cluster to a nondefault location, you may need to export the `LD_LIBRARY_PATH` to enable the test suite. The test suite also requires that the `test` database be available on the MySQL server.

NDB 7.3.1 also provided an alternative build script in `share/node.js/setup`; this was removed in NDB 7.3.2 and later NDB Cluster 7.3 releases.

5.3 Connector for JavaScript API Documentation

This section contains prototype descriptions and other information for the MySQL Connector for JavaScript.

5.3.1 Batch

This class represents a batch of operations.

```
Batch extends Context
```

```
execute(Function(Object error) callback);
```

Execute this batch. When a batch is executed, all operations are executed; the callback for each operation is called when that operation is executed (operations are not performed in any particular order). The `execute()` function's *`callback`* is also called.

A batch is executed in the context of the session's current state: this is autocommit if a transaction has not been started; this also includes the default lock mode and the partition key.

```
clear();
```

Clear this batch without affecting the transaction state. After being cleared, the batch is still valid, but all operations previously defined are removed; this restores the batch to a clean state.

The callbacks for any operations that are defined for this batch are called with an error indicating that the batch has been cleared.

This function requires no arguments.

```
getSession();
```

Get the session from which this batch was created.

This function requires no arguments.

5.3.2 Context

`Context` is the supertype of `Session` and `Batch`. It contains functions that are executed immediately if called from a session, or when the batch is executed.

The `Mynode` implementation does have any concept of a user and does not define any such property.

```
find(Function constructor, Object keys, Function(Object error, Object instance[, ...]) callback[, ...]);

find(String tableName, Object keys, Function(Object error, Object instance[, ...]) callback[, ...]);
```

Find a specific instance based on a primary key or unique key value.

You can use either of two versions of this function. In the first version, the *`constructor`* parameter is the constructor function of a mapped domain object. Alternatively, you can use the *`tableName`* instead, in the second variant of the function.

For both versions of `find()`, the *`keys`* may be of any type. A key must uniquely identify a single row in the database. If *`keys`* is a simple type (number or string), then the parameter type must be the same type as or compatible with the primary key type of the mapped object. Otherwise, properties are taken from the parameter and matched against property names in the mapping. Primary key properties are used if all are present, and other properties ignored. If *`keys`* cannot be used identify the primary key, property names corresponding to unique key columns are used instead. If no complete primary or unique key properties are found, an error is reported. The returned object is loaded based on the mapping and the current values in the database.

For multi-column primary or unique keys, all key fields must be set.

```
load(Object instance, Function(Object error) callback);
```

Load a specific instance by matching its primary or unique key with a database row, without creating a new domain object. (This is unlike `find()`, which creates a new, mapped domain object.)

The *`instance`* must have its primary or unique key value or values set. The mapped values in the object are loaded based on the current values in the database. Unmapped properties in the object are not changed.

Primary key properties are used if all are present, and all other properties are ignored; otherwise, property names corresponding to unique key columns are used. If no complete primary or unique key properties can be found, an error is reported.

The *callback* function is called with the parameters provided when the operation has completed. The *error* is the Node.js Error object; see Section 5.3.4, “Errors”, for more information.

```
persist(Object instance, Function(Object error) callback);

persist(Function constructor, Object values, Function(Object error) callback);

persist(String tableName, Object values, Function(Object error) callback);
```

Insert an instance into the database, unless the instance already exists in the database, in which case an exception is reported to a *callback* function. Autogenerated values are present in the instance when the *callback* is executed.

The role of an instance to be persisted can be fulfilled in any of three ways: by an instance object; by a constructor, with parameters, for a mapped domain object; or by table name and values to be inserted.

In all three cases, the *callback* function is called with the parameters provided, if any, when the operation has completed. The *error* is the Node.js Error object; see Section 5.3.4, “Errors”, for more information.

```
remove(Object instance, Function(Object error) callback);

remove(Function constructor, Object keys, Function(Object error) callback);

remove(String tableName, Object keys, Function(Object error) callback);
```

Delete an instance of a class from the database by a primary or unique key.

There are three versions of remove(); these allow you to delete an instance by referring to the *instance* object, to a *constructor* function, or by name of the table. The *instance* object must contain key values that uniquely identify a single row in the database. Otherwise, if the *keys* supplied with the function constructor or table name is a simple type (Number or String), then the parameter type must be of either the same type as or a type compatible with the primary key type of the mapped object. If *keys* is not a simple type, properties are taken from the parameter and matched against property names in the mapping. Primary key properties are used if all are present, and other properties ignored. If *keys* does not identify the primary key, property names corresponding to unique key columnsare used instead. If no complete primary or unique key properties are found, an error is reported to the *callback*.

All three versions of remove() call the *callback* function with the parameters provided, if any, when the operation is complete. The *error* object is a Node.js Error; see Section 5.3.4, “Errors”, for error codes.

```
update(Object instance, Function(Object error) callback);

update(Function constructor, keys, values, Function(Object error) callback);

update(String tableName, keys, values, Function(Object error) callback);
```

Update an instance in the database with the supplied *values* without retrieving it. The primary key is used to determine which instance is updated. If the instance does not exist in the database, an exception is reported in the *callback*.

As with the methods previously shown for persisting instances in and removing them from the database, update() exists in three variations, which allow you to use the *instance* as an object, an object *constructor* with *keys*, or by *tableName* and *keys*.

Unique key fields of the *keys* object determine which *instance* is to be updated. The *values* object provides values to be updated. If the *keys* object contains all fields corresponding to the primary key, the primary key identifies the instance. If not, unique keys are chosen is a nondeterministic manner.

Note

`update()` cannot be used to change the primary key.

```
save(Object instance, Function(Object error) callback);

save(Function constructor, Object values, Function(Object error) callback);

save(String tableName, Object values, Function(Object error) callback);
```

Save an instance in the database without checking for its existence. If the instance already exists, it is updated (as if you had used `update()`); otherwise, it is created (as if `persist()` had been used). The instance `id` property is used to determine which instance should be saved. As with `update()`, `persist()`, and `remove()`, this method allows you to specify the instance using an object, object constructor, or table name.

All three versions of the `save()` method call the *`callback`* function with any parameters provided when the operation has been completed. The *`error`* is a Node.js `Error` object; see Section 5.3.4, “Errors”, for error codes and messages.

```
Boolean isBatch()
```

`Context` also exposes an `isBatch()` instance method, which returns true if this `Context` is a `Batch`, and false if it is a `Session`. `isBatch()` takes no arguments.

5.3.3 Converter

Converter classes convert between JavaScript types and MySQL types. If the user supplies a JavaScript converter, it used to read and write to the database.

Converters have several purposes, including the following:

- To convert between MySQL `DECIMAL` types and a user's preferred JavaScript fixed-precision utility library
- To convert between MySQL `BIGINT` types and a user's preferred JavaScript big number utility library
- To serialize arbitrary application objects into character or binary columns

The ndb back end also uses converters to support `SET` and `ENUM` columns. (The mysql back end does not use these.)

A `Converter` class has the interface defined here:

```
function Converter() {}:

Converter.prototype = {
  "toDB"    : function(obj) {  },
  "fromDB"  : function(val) {  }
};
```

The `Converter` *must* implement the following two functions:

1. `toDB(obj)`: Convert an application object *`obj`* into a form that can be stored in the database.
2. `fromDB(val)`: Convert a value *`val`* read from the database into application object format.

Each function returns the result of the conversion.

Converter invocations are chained in the following ways:

- When writing to the database, first the registered `FieldConverter`, if any, is invoked. Later, any registered `TypeConverter` is invoked.

- When reading from the database, first the registered `TypeConverter`, if any, is invoked. Later, any registered `FieldConverter` is invoked.

5.3.4 Errors

The `Errors` object contains the error codes and message exposed by the MySQL Node.js adapters.

```
var Errors;

Errors = {
  /* Standard-defined classes, SQL-99 */
  "02000" : "No Data",

  // connection errors
  "08000" : "Connection error",
  "08001" : "Unable to connect to server",
  "08004" : "Connection refused",

  // data errors
  "22000" : "Data error",
  "22001" : "String too long",
  "22003" : "Numeric value out of range",
  "22008" : "Invalid datetime",

  // Constraint violations
  // 23000 includes both duplicate primary key and duplicate unique key
  "23000" : "Integrity Constraint Violation",

  // misc. errors
  "25000" : "Invalid Transaction State",
  "2C000" : "Invalid character set name",
  "42S02" : "Table not found",
  "IM001" : "Driver does not support this function",

  /* Implementation-defined classes (NDB) */
  "NDB00" : "Refer to ndb_error for details"
};
```

5.3.5 Mynode

This class is used to generate and obtain information about sessions (`Session` objects). To create an instance, use the Node.js `require()` function with the driver name, like this:

```
var nosql = require("mysql-js");
```

`ConnectionProperties` can be used to retrieve or set the connection properties for a given session. You can obtain a complete set of of default connection properties for a given adapter using the `ConnectionProperties` constructor, shown here, with the name of the adapter (a string) used as the value of *`nameOrProperties`*:

```
ConnectionProperties(nameOrProperties);
```

You can also create your own `ConnectionProperties` object by supplying a list of property names and values to a new `ConnectionProperties` object in place of the adapter name. Then you can use this object to set the connection properties for a new session, as shown here:

```
var NdbConnectionProperties = {
  "implementation" : "ndb",

  "ndb_connectstring" : "localhost:1186",
  "database"          : "test",
  "mysql_user"        : "root",

  "ndb_connect_retries" : 4,
  "ndb_connect_delay"   : 5,
  "ndb_connect_verbose" : 0,

  "linger_on_close_msec": 500,
```

```
  "use_ndb_async_api"   : false,

  "ndb_session_pool_min" : 4,
  "ndb_session_pool_max" : 100,
};

var sharePath = '/usr/local/mysql/share/nodejs';      // path to share/nodejs
var nosql = require(sharePath);
var dbProperties = nosql.ConnectionProperties(NdbConnectionProperties);
```

It is also possible to obtain an object with the adapter's default connection properties, after which you can update a selected number of these properties, then use the modified object to set connection properties for the session, as shown here:

```
var sharePath = '/usr/local/mysql/share/nodejs';      // path to share/nodejs
var spi   = require(sharePath + "/Adapter/impl/SPI"); // under share/nodejs

var serviceProvider         = spi.getDBServiceProvider('ndb');
var NdbConnectionProperties = serviceProvider.getDefaultConnectionProperties();

NdbConnectionProperties.mysql_user = 'nodejs_user';
NdbConnectionProperties.database   = 'my_nodejs_db';

var dbProperties = nosql.ConnectionProperties(NdbConnectionProperties);
```

The `ConnectionProperties` object includes the following properties:

- `implementation`: For Node.js applications using NDB Cluster, this is always “ndb”.
- `ndb_connectstring`: NDB Cluster connection string used to connect to the management server.
- `database`: Name of the MySQL database to use.
- `mysql_user`: MySQL user name.
- `ndb_connect_retries`: Number of times to retry a failed connection before timing out; use a number less than 0 for this to keep trying the connection without ever stopping.
- `ndb_connect_delay`: Interval in seconds between connection retries.
- `ndb_connect_verbose`: 1 or 0; 1 enables extra console output during connection.
- `linger_on_close_msec`: When a client closes a `DBConnectionPool`, the underlying connection is kept open for this many milliseconds in case another client tries to reuse it.
- `use_ndb_async_api`: If true, some operations are executed using asynchronous calls for improved concurrency. If false, the number of operations in transit is limited to one per worker thread.
- `ndb_session_pool_min`: Minimum number of `DBSession` objects per `NdbConnectionPool`.
- `ndb_session_pool_max`: Maximum number of `DBSession` objects per `NdbConnectionPool`.

  Each `NdbConnectionPool` maintains a pool of `DBSession` objects, along with their underlying `Ndb` objects. This parameter, together with `ndb_session_pool_min`, sets guidelines for the size of that pool.

The `TableMapping` constructor is also visible as a top-level function. You can get the mapping either by name, or by using an existing mapping:

```
TableMapping(tableName);

TableMapping(tableMapping);
```

```
openSession(properties, mappings, Function(err, Session) callback);
```

Connect to the data source and get a `Session` in the *`callback`* function. This is equivalent to calling `connect()` (see later in this section), and then calling `getSession()` on the `SessionFactory` that is returned in the callback function.

Note

Executing this method could result in connections being made to many other nodes on the network, waiting for them to become ready, and making multiple requests to them. You should avoid opening new sessions unnecessarily for this reason.

The implementation member of the *properties* object determines the implementation of the Session.

If *mappings* is undefined, null, or an empty array, no mappings are loaded or validated. In this case, any required mappings are loaded and validated when needed during execution. If *mappings* contains a string or a constructor function, the metadata for the table (or mapped table) is loaded from the database and validated against the requirements of the mapping.

Multiple tables and constructors may be passed to openSession() as elements in an array.

```
connect(properties, mappings, Function(err, SessionFactory) callback);
```

Connect to the data source to obtain a SessionFactory in the *callback* function. In order to obtain a Session, you must then call getSession() on this SessionFactory, whose implementation is determined by the implementation member of the *properties* object.

If *mappings* is undefined, null, or an empty array, no mappings are loaded or validated. In this case, any required mappings are loaded and validated when needed. If *mappings* contains a string or a constructor function, the metadata for the table (or mapped table) is loaded from the database and validated against the requirements of the mapping.

Multiple tables and constructors may be passed as elements in an array.

```
Array getOpenSessionFactories()
```

Get an array of all the SessionFactory objects that have been created by this module.

Note

The following functions are part of the public API but are not intended for application use. They form part of the contract between Mynode and SessionFactory.

- Connection()
- getConnectionKey()
- getConnection()
- newConnection()
- deleteFactory()

5.3.6 Session

A session is the main user access path to the database. The Session class models such a session.

```
Session extends Context
```

```
getMapping(Object parameter, Function(Object err, Object mapping) callback);
```

Get the mappings for a table or class.

The *parameter* may be a table name, a mapped constructor function, or a domain object. This function returns a fully resolved TableMapping object.

```
Batch createBatch()
```

Creates a new, empty batch for collecting multiple operations to be executed together. In an application, you can invoke this function similarly to what is shown here:

```
var nosql = require("mysql-js");

var myBatch = nosql.createBatch();
```

```
Array listBatches():
```

Return an array whose elements consist of all current batches belonging to this session.

```
Transaction currentTransaction();
```

Get the current `Transaction`.

```
void close(Function(Object error) callback);
```

Close this session. Must be called when the session is no longer needed.

```
boolean isClosed();
```

Returns true if this session is closed.

```
void setLockMode(String lockMode);
```

Set the lock mode for read operations. This takes effect immediately and remains in effect until the session is closed or this method is called again. *`lockMode`* must be one of `'EXCLUSIVE'`, `'SHARED'`, OR `'NONE'`.

```
Array listTables(databaseName, callback);
```

List all tables in database *`databaseName`*.

```
TableMetadata getTableMetadata(String databaseName, String tableName, callback);
```

Fetch metadata for table *`tableName`* in database *`databaseName`*.

5.3.7 SessionFactory

This class is used to generate and manage sessions. A `Session` provides a context for database transactions and operations. Each independent user should have its own session.

```
openSession(Object mappings, Function(Object error, Session session) callback);
```

Open a database session object. Table *`mappings`* are validated at the beginning of the session. Resources required for sessions are allocated in advance; if those resources are not available, the method returns an error in the callback.

```
Array getOpenSessions();
```

Get all open sessions that have been created by this `SessionFactory`.

```
close(Function(Error err));
```

Close the connection to the database. This ensures proper disconnection. The function passed in is called when the close operation is complete.

5.3.8 TableMapping and FieldMapping

A `TableMapping` describes the mapping of a domain object in the application to a table stored in the database. A *default* table mapping is one which maps each column in a table to a field of the same name.

```
TableMapping = {
  String table                  :  "" ,
  String database               :  "" ,
  boolean mapAllColumns         : true,
```

```
  Array fields                    : null
};
```

The `table` and `data` members are the names of the table and database, respectively. `mapAllColumns`, if true, creates a default `FieldMapping` for all columns not listed in `fields`, such that that all columns not explicitly mapped are given a default mapping to a field of the same name. `fields` holds an array of `FieldMapping` objects;this can also be a single `FieldMapping`.

A `FieldMapping` describes a single field in a domain object. There is no public constructor for this object; you can create a FieldMapping using `TableMapping.mapField()`, or you can use `FieldMapping` literals can be used directly in the `TableMapping` constructor.

```
FieldMapping = {
  String fieldName     :  "" ,
  String columnName    :  "" ,
  Boolean persistent    : true,
  Converter converter     : null
};
```

`fieldName` and `columnName` are the names of the field and the column where this field are stored, respectively, in the domain object. If `persistent` is true (the default), the field is stored in the database. `converter` specifies a `Converter` class, if any, to use with this field (defaults to null). };

The `TableMapping` constructor can take either the name of a table (possibly qualified with the database name) or a `TableMapping` literal.

```
TableMapping mapField(String fieldName, [String columnName], [Converter converter], [Boolean persistent])
```

Create a field mapping for a named field of a mapped object. The only mandatory parmeter is *`fieldName`*, which provides the name a field in a JavaScript application object. The remaining parameters are optional, and may appear in any order. The cyrrent `TableMapping` object is returned.

`columnName` specifies the name of the database column that maps to this object field. If omitted, *`columnName`* defaults to the same value as *`fieldName`*. A *`converter`* can be used to supply a `Converter` class that performs custom conversion between JavaScript and database data types. The default is null. *`persistent`* specifies whether the field is persisted to the database, and defaults to true.

Important

If *`persistent`* is false, then the *`columnName`* and *`converter`* parameters may not be used.

```
TableMapping applyToClass(Function constuctor)
```

Attach a `TableMapping` to a *`constructor`* for mapped objects. After this is done, any object created from the constructor will qualify as a mapped instance, which several forms of the relevant `Session` and `Batch` methods can be used.

For example, an application can construct an instance that is only partly complete, then use `Session.load()` to populate it with all mapped fields from the database. After the application modifies the instance, `Session.save()` saves it back. Similarly, `Session.find()` can take the mapped constructor, retrieve an object based on keys, and then use the constructor to create a fully-fledged domain object.

5.3.9 TableMetadata

A `TableMetadata` object represents a table. This is the object returned in the `getTable()` callback. `indexes[0]` represents the table's intrinsic primary key.

```
TableMetadata = {
  database          : ""    ,  // Database name
  name              : ""    ,  // Table Name
  columns           : {}    ,  // ordered array of ColumnMetadata objects
```

```
  indexes           : {}    ,  // array of IndexMetadata objects
  partitionKey      : {}    ,  // ordered array of column numbers in the partition key
};
```

`ColumnMetadata` object represents a table column.

```
ColumnMetadata = {
  /* Required Properties */
  name              : ""    ,  // column name
  columnNumber      : -1    ,  // position of column in table, and in columns array
  columnType        : ""    ,  // a ColumnTypes value
  isIntegral        : false ,  // true if column is some variety of INTEGER type
  isNullable        : false ,  // true if NULLABLE
  isInPrimaryKey    : false ,  // true if column is part of PK
  isInPartitionKey : false ,  // true if column is part of partition key
  columnSpace       : 0     ,  // buffer space required for encoded stored value
  defaultValue      : null  ,  // default value for column: null for default NULL;
                               // undefined for no default; or a type-appropriate
                               // value for column

  /* Optional Properties, depending on columnType */
  /* Group A: Numeric */
  isUnsigned        : false ,  //  true for UNSIGNED
  intSize           : null  ,  //  1,2,3,4, or 8 if column type is INT
  scale             : 0     ,  //  DECIMAL scale
  precision         : 0     ,  //  DECIMAL precision
  isAutoincrement   : false ,  //  true for AUTO_INCREMENT columns

  /* Group B: Non-numeric */
  length            : 0     ,  //  CHAR or VARCHAR length in characters
  isBinary          : false ,  //  true for BLOB/BINARY/VARBINARY
  charsetNumber     : 0     ,  //  internal number of charset
  charsetName       : ""    ,  //  name of charset
};
```

An `IndexMetadata` object represents a table index. The `indexes` array of `TableMetadata` contains one `IndexMetadata` object per table index.

`NDB` implements a primary key as both an ordered index and a unique index, and might be viewed through the NDB API adapter as two indexes, but through a MySQL adapter as a single index that is both unique and ordered. We tolerate this discrepancy and note that the implementation in `Adapter/api` must treat the two descriptions as equivalent.

```
IndexMetadata = {
  name              : ""    ,  // Index name; undefined for PK
  isPrimaryKey      : true  ,  // true for PK; otherwise undefined
  isUnique          : true  ,  // true or false
  isOrdered         : true  ,  // true or false; can scan if true
  columns           : null  ,  // an ordered array of column numbers
};
```

The `ColumnMetaData` object's `columnType` must be a valid `ColumnTypes` value, as shown in this object's definition here:

```
ColumnTypes =  [
  "TINYINT",
  "SMALLINT",
  "MEDIUMINT",
  "INT",
  "BIGINT",
  "FLOAT",
  "DOUBLE",
  "DECIMAL",
  "CHAR",
  "VARCHAR",
  "BLOB",
  "TEXT",
  "DATE",
  "TIME",
  "DATETIME",
```

```
  "YEAR",
  "TIMESTAMP",
  "BIT",
  "BINARY",
  "VARBINARY"
];
```

5.3.10 Transaction

A transaction is always either automatic or explicit. If it is automatic, (autocommit), every operation is performed as part of a new transaction that is automatically committed.

Beginning, committing, and rolling back a transaction

```
begin();
```

Begin a transaction. No arguments are required. If a transaction is already active, an exception is thrown.

```
commit(Function(Object error) callback);
```

Commit a transaction.

This method takes as its sole argument a *`callback`* function that returns an error object.

```
rollback(Function(Object error) callback);
```

Roll back a transaction. Errors are reported in the *`callback`* function.

Transaction information methods

```
Boolean isActive();
```

Determine whether or not a given transaction is currently active. Returns true if a transaction is active, and false otherwise.

`isActive()` requires no arguments.

```
setRollbackOnly();
```

Mark the transaction as rollback-only. Once this is done, `commit()` rolls back the transaction and throws an exception; `rollback()` rolls the transaction back, but does not throw an exception. To mark a transaction as rollback-only, call the `setRollbackOnly()` method, as shown here.

This method is one-way; a transaction marked as rollback-only cannot be unmarked. Invoking `setRollbackOnly()` while in autocommit mode throws an exception. This method requires no arguments.

```
boolean getRollbackOnly();
```

Determine whether a transaction has been marked as rollback-only. Returns true if the transaction has been so marked. `setRollbackOnly()` takes no arguments.

5.4 Using the MySQL JavaScript Connector: Examples

This section contains a number of examples performing basic database operations such as retrieving, inserting, or deleting rows from a table. The source for these files ca also be found in `share/nodejs/samples`, under the NDB Cluster installation directory.

5.4.1 Requirements for the Examples

The software requirements for running the examples found in the next few sections are as follows:

- A working Node.js installation
- Working installations of the `ndb` and `mysql-js` adapters

- The `mysql-js` adapter also requires a working installation of the `node-mysql` driver from https://github.com/felixge/node-mysql/.

Section 5.2, “Installing the JavaScript Connector”, describes the installation process for all three of these requirements.

Sample database, table, and data. All of the examples use a sample table named `tweet`, in the `test` database. This table is defined as in the following `CREATE TABLE` statement:

```
CREATE TABLE IF NOT EXISTS tweet  (
    id CHAR(36) NOT NULL PRIMARY KEY,
    author VARCHAR(20),
    message VARCHAR(140),
    date_created TIMESTAMP,

    KEY idx_btree_date_created (date_created),
    KEY idx_btree_author(author)
)
ENGINE=NDB;
```

The `tweet` table can be created by running the included SQL script `create.sql` in the `mysql` client. You can do this by invoking `mysql` in your system shell, as shown here:

```
shell> mysql < create.sql
```

All of the examples also make use of two modules defined in the file `lib.js`, whose contents are reproduced here:

```
# FILE: lib.js

"use strict";

var udebug = unified_debug.getLogger("samples/lib.js");
var exec = require("child_process").exec;
var SQL = {};

/* Pseudo random UUID generator */

var randomUUID = function() {
  return 'xxxxxxxx-xxxx-4xxx-yxxx-xxxxxxxxxxxx'.replace(/[xy]/g, function(c) {
    var r = Math.random()*16|0, v = c == 'x' ? r : (r&0x3|0x8);
    return v.toString(16);
    });
};

/* Tweet domain object model */

var Tweet = function(author, message) {
  this.id = randomUUID();
  this.date_created = new Date();
  this.author = author;
  this.message = message;
};

/* SQL DDL Utilities */

var runSQL = function(sqlPath, source, callback) {

  function childProcess(error, stdout, stderr) {
    udebug.log('harness runSQL process completed.');
    udebug.log(source + ' stdout: ' + stdout);
    udebug.log(source + ' stderr: ' + stderr);
    if (error !== null) {
      console.log(source + 'exec error: ' + error);
    } else {
      udebug.log(source + ' exec OK');
    }
    if(callback) {
      callback(error);
    }
  }
```

```
  var p = mysql_conn_properties;
  var cmd = 'mysql';
  if(p) {
    if(p.mysql_socket)     { cmd += " --socket=" + p.mysql_socket; }
    else if(p.mysql_port)  { cmd += " --port=" + p.mysql_port; }
    if(p.mysql_host)     { cmd += " -h " + p.mysql_host; }
    if(p.mysql_user)     { cmd += " -u " + p.mysql_user; }
    if(p.mysql_password) { cmd += " --password=" + p.mysql_password; }
  }
  cmd += ' <' + sqlPath;
  udebug.log('harness runSQL forking process...');
  var child = exec(cmd, childProcess);
};

SQL.create =  function(suite, callback) {
  var sqlPath = path.join(suite.path, 'create.sql');
  udebug.log_detail("createSQL path: " + sqlPath);
  runSQL(sqlPath, 'createSQL', callback);
};

SQL.drop = function(suite, callback) {
  var sqlPath = path.join(suite.path, 'drop.sql');
  udebug.log_detail("dropSQL path: " + sqlPath);
  runSQL(sqlPath, 'dropSQL', callback);
};


/* Exports from this module */
exports.SQL               = SQL;
exports.Tweet             = Tweet;
```

Finally, a module used for random data generation is included in the file `ndb_loader/lib/RandomData.js`, shown here:

```
# FILE: RandomData.js

var assert = require("assert");


function RandomIntGenerator(min, max) {
  assert(max > min);
  var range = max - min;
  this.next = function() {
    var x = Math.floor(Math.random() * range);
    return min + x;
  };
}


function SequentialIntGenerator(startSeq) {
  var seq = startSeq - 1;
  this.next = function() {
    seq += 1;
    return seq;
  };
}


function RandomFloatGenerator(min, max, prec, scale) {
  assert(max > min);
  this.next = function() {
    var x = Math.random();
    /* fixme! */
    return 100 * x;
  };
}


function RandomCharacterGenerator() {
  var intGenerator = new RandomIntGenerator(32, 126);
  this.next = function() {
```

```
    return String.fromCharCode(intGenerator.next());
  };
}


function RandomVarcharGenerator(length) {
  var lengthGenerator = new RandomIntGenerator(0, length),
      characterGenerator = new RandomCharacterGenerator();
  this.next = function() {
    var i = 0,
        str = "",
        len = lengthGenerator.next();
    for(; i < len ; i++) str += characterGenerator.next();
    return str;
  }
}


function RandomCharGenerator(length) {
  var characterGenerator = new RandomCharacterGenerator();
  this.next = function() {
    var i = 0,
        str = "";
    for(; i < length ; i++) str += characterGenerator.next();
    return str;
  };
}


function RandomDateGenerator() {
  var generator = new RandomIntGenerator(0, Date.now());
  this.next = function() {
    return new Date(generator.next());
  };
}


function RandomGeneratorForColumn(column) {
  var g = {},
      min, max, bits;

  switch(column.columnType.toLocaleUpperCase()) {
    case "TINYINT":
    case "SMALLINT":
    case "MEDIUMINT":
    case "INT":
    case "BIGINT":
      if(column.isInPrimaryKey) {
        g = new SequentialIntGenerator(0);
      }
      else {
        bits = column.intSize * 8;
        max = column.isUnsigned ? Math.pow(2,bits)-1 : Math.pow(2, bits-1);
        min = column.isUnsigned ?                  0 : 1 - max;
        g = new RandomIntGenerator(min, max);
      }
      break;
    case "FLOAT":
    case "DOUBLE":
    case "DECIMAL":
      g = new RandomFloatGenerator(0, 100000); // fixme
      break;
    case "CHAR":
      g = new RandomCharGenerator(column.length);
      break;
    case "VARCHAR":
      g = new RandomVarcharGenerator(column.length);
      break;
    case "TIMESTAMP":
      g = new RandomIntGenerator(0, Math.pow(2,32)-1);
      break;
    case "YEAR":
```

```
      g = new RandomIntGenerator(1900, 2155);
      break;
    case "DATE":
    case "TIME":
    case "DATETIME":
      g = new RandomDateGenerator();
      break;
    case "BLOB":
    case "TEXT":
    case "BIT":
    case "BINARY":
    case "VARBINARY":
    default:
      throw("UNSUPPORTED COLUMN TYPE " + column.columnType);
      break;
  }

  return g;
}


function RandomRowGenerator(table) {
  var i = 0,
      generators = [];
  for(; i < table.columns.length ; i++) {
    generators[i] = RandomGeneratorForColumn(table.columns[i]);
  }

  this.newRow = function() {
    var n, col, row = {};
    for(n = 0; n < table.columns.length ; n++) {
      col = table.columns[n];
      row[col.name] = generators[n].next();
    }
    return row;
  };
}

exports.RandomRowGenerator = RandomRowGenerator;
exports.RandomGeneratorForColumn = RandomGeneratorForColumn;
```

5.4.2 Example: Finding Rows

```
# FILE: find.js

var nosql = require('..');
var lib = require('./lib.js');
var adapter = 'ndb';
global.mysql_conn_properties = {};

var user_args = [];

// *** program starts here ***

// analyze command line

var usageMessage =
  "Usage: node find key\n" +
  "           -h or --help: print this message\n" +
  "          -d or --debug: set the debug flag\n" +
  "   --mysql_socket=value: set the mysql socket\n" +
  "     --mysql_port=value: set the mysql port\n" +
  "     --mysql_host=value: set the mysql host\n" +
  "     --mysql_user=value: set the mysql user\n" +
  "--mysql_password=value: set the mysql password\n" +
  "               --detail: set the detail debug flag\n" +
  "    --adapter=<adapter>: run on the named adapter (e.g. ndb or mysql)\n"
  ;

// handle command line arguments
var i, exit, val, values;
```

```
for(i = 2; i < process.argv.length ; i++) {
  val = process.argv[i];
  switch (val) {
  case '--debug':
  case '-d':
    unified_debug.on();
    unified_debug.level_debug();
    break;
  case '--detail':
    unified_debug.on();
    unified_debug.level_detail();
    break;
  case '--help':
  case '-h':
    exit = true;
    break;
  default:
    values = val.split('=');
    if (values.length === 2) {
      switch (values[0]) {
      case '--adapter':
        adapter = values[1];
        break;
      case '--mysql_socket':
        mysql_conn_properties.mysql_socket = values[1];
        break;
      case '--mysql_port':
        mysql_conn_properties.mysql_port = values[1];
        break;
      case '--mysql_host':
        mysql_conn_properties.mysql_host = values[1];
        break;
      case '--mysql_user':
        mysql_conn_properties.mysql_user = values[1];
        break;
      case '--mysql_password':
        mysql_conn_properties.mysql_password = values[1];
        break;
      default:
        console.log('Invalid option ' + val);
        exit = true;
      }
    } else {
      user_args.push(val);
   }
  }
}

if (user_args.length !== 1) {
  console.log(usageMessage);
  process.exit(0);
};

if (exit) {
  console.log(usageMessage);
  process.exit(0);
}

console.log('Running find with adapter', adapter, user_args);
//create a database properties object

var dbProperties = nosql.ConnectionProperties(adapter);

// create a basic mapping
var annotations = new nosql.TableMapping('tweet').applyToClass(lib.Tweet);

//check results of find
var onFind = function(err, object) {
  console.log('onFind.');
  if (err) {
    console.log(err);
  } else {
```

```
    console.log('Found: ' + JSON.stringify(object));
  }
  process.exit(0);
};

// find an object
var onSession = function(err, session) {
  if (err) {
    console.log('Error onSession.');
    console.log(err);
    process.exit(0);
  } else {
    session.find(lib.Tweet, user_args[0], onFind);
  }
};

// connect to the database
nosql.openSession(dbProperties, annotations, onSession);
```

5.4.3 Inserting Rows

```
# FILE: insert.js


var nosql = require('..');
var lib = require('./lib.js');
var adapter = 'ndb';
global.mysql_conn_properties = {};

var user_args = [];
// *** program starts here ***

// analyze command line

var usageMessage =
  "Usage: node insert author message\n" +
  "          -h or --help: print this message\n" +
  "         -d or --debug: set the debug flag\n" +
  "  --mysql_socket=value: set the mysql socket\n" +
  "    --mysql_port=value: set the mysql port\n" +
  "    --mysql_host=value: set the mysql host\n" +
  "    --mysql_user=value: set the mysql user\n" +
  "--mysql_password=value: set the mysql password\n" +
  "              --detail: set the detail debug flag\n" +
  "   --adapter=<adapter>: run on the named adapter (e.g. ndb or mysql)\n"
  ;

// handle command line arguments
var i, exit, val, values;

for(i = 2; i < process.argv.length ; i++) {
  val = process.argv[i];
  switch (val) {
  case '--debug':
  case '-d':
    unified_debug.on();
    unified_debug.level_debug();
    break;
  case '--detail':
    unified_debug.on();
    unified_debug.level_detail();
    break;
  case '--help':
  case '-h':
    exit = true;
    break;
  default:
    values = val.split('=');
    if (values.length === 2) {
      switch (values[0]) {
      case '--adapter':
        adapter = values[1];
```

```
        break;
      case '--mysql_socket':
        mysql_conn_properties.mysql_socket = values[1];
        break;
      case '--mysql_port':
        mysql_conn_properties.mysql_port = values[1];
        break;
      case '--mysql_host':
        mysql_conn_properties.mysql_host = values[1];
        break;
      case '--mysql_user':
        mysql_conn_properties.mysql_user = values[1];
        break;
      case '--mysql_password':
        mysql_conn_properties.mysql_password = values[1];
        break;
      default:
        console.log('Invalid option ' + val);
        exit = true;
      }
    } else {
      user_args.push(val);
   }
  }
}

if (user_args.length !== 2) {
  console.log(usageMessage);
  process.exit(0);
};

if (exit) {
  console.log(usageMessage);
  process.exit(0);
}

console.log('Running insert with adapter', adapter, user_args);
//create a database properties object

var dbProperties = nosql.ConnectionProperties(adapter);

// create a basic mapping
var annotations = new nosql.TableMapping('tweet').applyToClass(lib.Tweet);

//check results of insert
var onInsert = function(err, object) {
  console.log('onInsert.');
  if (err) {
    console.log(err);
  } else {
    console.log('Inserted: ' + JSON.stringify(object));
  }
  process.exit(0);
};

// insert an object
var onSession = function(err, session) {
  if (err) {
    console.log('Error onSession.');
    console.log(err);
    process.exit(0);
  } else {
    var data = new lib.Tweet(user_args[0], user_args[1]);
    session.persist(data, onInsert, data);
  }
};

// connect to the database
nosql.openSession(dbProperties, annotations, onSession);
```

5.4.4 Deleting Rows

```
FILE: delete.js


var nosql = require('..');
var lib = require('./lib.js');
var adapter = 'ndb';
global.mysql_conn_properties = {};

var user_args = [];
// *** program starts here ***

// analyze command line

var usageMessage =
  "Usage: node delete message-id\n" +
  "          -h or --help: print this message\n" +
  "         -d or --debug: set the debug flag\n" +
  "  --mysql_socket=value: set the mysql socket\n" +
  "    --mysql_port=value: set the mysql port\n" +
  "    --mysql_host=value: set the mysql host\n" +
  "    --mysql_user=value: set the mysql user\n" +
  "--mysql_password=value: set the mysql password\n" +
  "              --detail: set the detail debug flag\n" +
  "   --adapter=<adapter>: run on the named adapter (e.g. ndb or mysql)\n"
  ;

// handle command line arguments
var i, exit, val, values;

for(i = 2; i < process.argv.length ; i++) {
  val = process.argv[i];
  switch (val) {
  case '--debug':
  case '-d':
    unified_debug.on();
    unified_debug.level_debug();
    break;
  case '--detail':
    unified_debug.on();
    unified_debug.level_detail();
    break;
  case '--help':
  case '-h':
    exit = true;
    break;
  default:
    values = val.split('=');
    if (values.length === 2) {
      switch (values[0]) {
      case '--adapter':
        adapter = values[1];
        break;
      case '--mysql_socket':
        mysql_conn_properties.mysql_socket = values[1];
        break;
      case '--mysql_port':
        mysql_conn_properties.mysql_port = values[1];
        break;
      case '--mysql_host':
        mysql_conn_properties.mysql_host = values[1];
        break;
      case '--mysql_user':
        mysql_conn_properties.mysql_user = values[1];
        break;
      case '--mysql_password':
        mysql_conn_properties.mysql_password = values[1];
        break;
      default:
        console.log('Invalid option ' + val);
        exit = true;
```

```
      }
    } else {
      user_args.push(val);
   }
  }
}

if (user_args.length !== 1) {
  console.log(usageMessage);
  process.exit(0);
};

if (exit) {
  console.log(usageMessage);
  process.exit(0);
}

console.log('Running delete with adapter', adapter, user_args);
//create a database properties object

var dbProperties = nosql.ConnectionProperties(adapter);

// create a basic mapping
var annotations = new nosql.TableMapping('tweet').applyToClass(lib.Tweet);

// check results of delete
var onDelete = function(err, object) {
  console.log('onDelete.');
  if (err) {
    console.log(err);
  } else {
    console.log('Deleted: ' + JSON.stringify(object));
  }
  process.exit(0);
};

// delete an object
var onSession = function(err, session) {
  if (err) {
    console.log('Error onSession.');
    console.log(err);
    process.exit(0);
  } else {
    var tweet = new lib.Tweet();
    tweet.id = user_args[0];
    session.remove(tweet, onDelete, user_args[0]);
  }
};

// connect to the database
nosql.openSession(dbProperties, annotations, onSession);
```

Chapter 6 ndbmemcache—Memcache API for NDB Cluster

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This section provides information about the Memcache API for NDB Cluster, which makes it possible to access NDB Cluster data using the memcache protocol.

6.1 Overview

Memcached is a distributed in-memory caching server using a simple text-based protocol, commonly used for key-value data stores, with clients available for many platforms and programming languages. The most recent release of the `memcached` server is available from memcached.org.

The Memcache API for NDB Cluster is implemented as a loadable storage engine for memcached version 1.6 and later, which employs a storage engine architecture. This API can be used to provide a persistent NDB Cluster data store which is accessible employing the memcache protocol. It is also possible for the `memcached` server to provide a strictly defined interface to existing NDB Cluster tables such that an administrator can control exactly which tables and columns are referenced by particular memcache keys and values, and which operations are allowed on these keys and values.

The standard `memcached` caching engine is included in the NDB Cluster distribution. Each memcache server, in addition to providing direct access to data stored in NDB Cluster, is able to cache data locally and serve (some) requests from this local cache. As with table and column mappings, cache policies are configurable based on a prefix of a memcache key.

6.2 Compiling NDB Cluster with Memcache Support

Support for the Memcache API is built automatically using the memcached and libevent sources included in the NDB Cluster sources when compiling NDB from source. By default, `make install` places the `memcached` binary in the NDB Cluster installation `bin` directory, and the ndbmemcache engine shared object file `ndb_engine.so` in the installation `lib` directory.

You can disable use of the bundled memcached when building ndbmemcache, by using `-DWITH_BUNDLED_MEMCACHED=OFF`; you can instead use your own system's memcached server and sources, installed in *`path`*, with `-DWITH_BUNDLED_MEMCACHED=OFF -DMEMCACHED_HOME=path`. You can also cause your system's version of libevent to be used, rather than the version bundled with NDB Cluster, by using the `-DWITH_BUNDLED_LIBEVENT=OFF` option.

For additional information about `CMake` options relating to ndbmemcache support, see Options for Compiling NDB Cluster.

For general information about building NDB Cluster, see Building NDB Cluster from Source on Linux, and Compiling and Installing NDB Cluster from Source on Windows. For information about building MySQL Server from source, see Installing MySQL from Source, as well as MySQL Source-Configuration Options.

6.3 memcached command line options

The following list contains memcached command line options that are of particular interest or usefulness when working with ndbmemcache.

- `-E so_file`

  Specifies an engine (module) to be dynamically loaded on startup by memcached (version 1.6 or later).

  If this option is not specified, memcached tries to load the default engine, which provides the same caching engine as used in memcached 1.4 and previous versions

  To load the NDB engine, use this option as shown here:

  ```
  -E /path/to/ndb_engine.so
  ```

- `-e "configuration_string"`

  Specifies options for use by the loaded engine. Options are given as *option=value* pairs separated by semicolons. The complete string should be quoted to prevent the possibility that the shell might interpret the semicolon as a command separator. All options to be passed to the NDB memcached engine must be specified in this fashion, as shown in the following example:

  ```
  shell> memcached -E lib/ndb_engine.so -e "connectstring=maddy:1186;role=dev"
  ```

  See Section 6.4, "NDB Engine Configuration" for a list of NDB memcached engine configuration options.

- `-t number_of_worker_threads`

  Sets the number of worker threads to be used by memcached. Because memcached uses an event-driven model in which each worker thread should be able to saturate a CPU core, the number of worker threads should be approximately the same as the number of CPU cores that memcached is to use.

  In some cases, adding worker threads does not improve performance unless you also provide additional connections to NDB Cluster. The default (4 memcached threads and 2 cluster connections) should work in most cases.

- `-p tcp_port`

  The default TCP port is port 11211.

- `-U udb_port`

  The default UDP port is port 11211. Setting this option to 0 disables UDP support.

- `-h`

  Causes memcached to print help information.

For general information memcached command line options, see the documentation at http://code.google.com/p/memcached/wiki/NewStart.

6.4 NDB Engine Configuration

NDB memcache engine configuration options. The NDB engine supports the following configuration options for use with `memcache -e` (see Section 6.3, "memcached command line options"):

- `debug={true|false}`

Enables writing of debug tracing output to `stderr` or the memcached log file, as shown in this example:

```
shell> memcached -E lib/ndb_engine.so -e "debug=true"
```

Because the debug output can be quite large, you should enable this option as a diagnostic tool only, and not in production.

By default, this option is `false`.

- `connectstring=connect_string`

  This option takes as its value an NDB Cluster connection string (see NDB Cluster Connection Strings) pointing to the primary NDB Cluster—that is, the NDB Cluster in which the `ndbmemcache` configuration database is stored, as shown here:

  ```
  shell > memcached -E lib/ndb_engine.so -e "connectstring=sam:1186;debug=true"
  ```

  The default value is `localhost:1186`.

- `reconf={true|false}`

  Enables online reconfiguration (reloading of the configuration stored in the `ndbmemcache` information database).

  This option is enabled (`true`) by default.

- `role=role_name`

  Sets the role assumed by this memcached server. A role corresponds to a set of key-prefix mappings described in the `ndbmemcache` configuration database, identified by a *`role_name`* found in the `ndbmemcache.memcache_server_roles` table.

  The default role is `default_role`.

  An example is shown here:

  ```
  shell> memcached -E lib/ndb_engine.so -e "role=db-only"
  ```

- `scheduler=scheduler_name:scheduler_options`

  This option controls some advanced aspects of how the NDB engine sends requests to NDB Cluster. The *`scheduler_name`* of the default scheduler or *S-scheduler* is `S`. An S-scheduler option takes the form of a single letter followed by a number; multiple S-scheduler options are separated by commas. In most cases, the default value `S:c0,f0,t1` is sufficient.

  These S-scheduler options are described in the following list:

  - `c`: Number of connections to `NDB`. Possible values are in the range 0-4 inclusive, with 0 (the default) causing this number to be calculated automatically. Using 1, 2, 3, or 4 causes that number of connections to be created.
  - `f`: Can be either 0 or 1; setting to 1 enables force-send. The default is 0 (force-send disabled).
  - `t`: Sets the send-thread timer to 1-10 milliseconds (inclusive). The default is 1.

Initial Configuration.
When a the NDB engine starts up, its most important command-line arguments are the cluster connection string and server role. The connection string is used to connect to a particular cluster, called the primary cluster, which contains a configuration schema. The tables in the configuration schema are read to retrieve a set of key-prefix mappings for the given server role (see the ndbmemcache configuration schema). Those mappings instruct the server how to respond to memcache operations

on particular keys, based on the leftmost part of the key. For instance, they may specify that data is stored in particular columns of a certain table. This table may be stored in the same cluster as the configuration schema, or in a different cluster. A memcache server may have connections to several different clusters, and many memcache servers may connect to a single cluster but with a variety of roles.

The ndbmemcache configuration schema. When the memcache NDB engine starts up, it connects to a cluster, and looks for the ndbmemcache configuration schema there. If the schema is not found, it shuts down.

The schema is described (with full comments) in the file ndb_memcache_metadata.sql

The main concept of the schema is a key-prefix mapping. This takes a prefix of a memcache key and maps it to a specific container table, on a particular cluster, with a particular cache policy.

A server role is defined as a set of key-prefix mappings that a memcached server will implement.

Whenever a memcached server is started with a particular server role (from the command-line arguments), that server role must exist in the ndbmemcache.server_roles table.

The following table lists table names and descriptions for tables that belong to the `ndbmemcache` configuration schema.

Table 6.1 ndbmemcache configuration schema, table names and descriptions

Table Name	Description
`meta`	The meta table describes the version number of the ndbmemcache tables. It should be considered as a read-only table.
`ndb_clusters`	For each cluster, this table holds a numeric cluster-id and a connection string. The microsec_rtt column is used for performance tuning. It is recommended to use the default value of this column. See Autotuning.
`cache_policies`	This table maps a policy name to a set of get, set, delete, and flush policies. The `policy_name` column is used as the key (there is no numeric policy id). Additional information about cache policies can found in the text following the table.
`containers`	The containers table describes how the memcached server can use a database table to store data. Additional information about containers can found in the text following the table.
`memcache_server_roles`	The `memcache_server_roles` table maps a role name to a numeric ID and a `max_tps` specifier, which is used for performance tuning. See Autotuning. It is recommended to use the default value. This table also has an update_timestamp column. This column can be updated to enable online reconfiguration. See Online reconfiguration. Additional information about server roles can found in the text following the table.
`key_prefixes`	In this table, the leftmost part of a memcache key is paired with a cluster ID, container, and cache policy to make a *key prefix mapping*. Additional information about key prefix mappings can found in the text following the table.

Cache policies. There are four policy types: `get_policy`, `set_policy`, `delete_policy`, and `flush_from_db`. These are described in the following paragraphs.

`get_policy` determines how the memcached server interprets `GET` commands. Possible values and their meanings are shown in the following list:

- `cache_only`: The server searches in its local cache only.
- `ndb_only`: The server searches in the NDB Cluster database only.
- `caching`: The server searches the local cache first, then the NDB Cluster database.
- `disabled`: `GET` commands are not permitted.

The `set_policy` determines how the memcached server interprets `SET`, `INSERT`, and `REPLACE` commands. Possible `set_policy` values and their meanings are listed here:

- `cache_only`: The server updates the value in its local cache only.
- `ndb_only`: The server updates the value stored in NDB Cluster only.
- `caching`: The server updates the value stored in NDB Cluster, and then stores a copy of that value in its local cache.
- `disabled`: `SET`, `INSERT`, and `REPLACE` commands are not allowed.

`delete_policy` describes how the memcached server interprets `DELETE` commands. It can take on the values shown and described in the following list:

- `cache_only`: The server deletes the value from its local cache only.
- `ndb_only`: The server deletes the value from the NDB Cluster database only.
- `caching`: The server deletes the value from both the database and its local cache.
- `disabled`: `DELETE` operations are not allowe.

`flush_from_db` determines how the memcached server interprets a `FLUSH_ALL` command with regard to data stored in the NDB Cluster database, as shown here:

- `true`: `FLUSH_ALL` commands cause data to be deleted from the NDB Cluster database.
- `false`: `FLUSH_ALL` commands do not affect the NDB Cluster database.

containers table columns. The columns in the `containers` table are described in the following list:

- `name`: Name of container; primary key of table.
- `db_schema`: Name of database (schema) holding container table.
- `db_table`: table name of container table.
- `key_columns`: List of columns that map to the memcache key. Most keys are one-part keys, but a key can have up to four parts, in which case multiple columns are listed and separated by commas.
- `value_columns`: List of columns that map to the memcache value. It can also contain a comma-separated list of up to 16 value columns.
- `flags`: Currently unimplemented; it is intended hold either a numeric value which is used as the memcache `FLAGS` value for the entire container, or the name of that column of the container table used to store this value.
- `increment_column`: Name of the column in the container table which stores the numeric value used in memcached `INCR` and `DECR` operations. If set, this must be a `BIGINT UNSIGNED` column.
- `cas_column` Name of the column in the container table storing the memcache CAS value. If set, it must be a `BIGINT UNSIGNED` column.

- `expire_time_column`: Currently unimplemented.

Key mappings.

- server_role_id is a numeric server role identifier which references the memcache_server_roles table
- key_prefix is a string that corresponds to the leftmost part of the memcache key. If this string is empty, then the defined prefix will be the "default prefix". The default prefix matches any memcache key that does not match some more specific prefix.
- cluster_id is an int that references the ndb_clusters table
- policy is a string that references a policy name in the cache_policies table
- container is a container name that references the containers table

The following table lists table names and descriptions for non-configuration `ndbmemcache` logging and container tables.

Table 6.2 ndbmemcache logging and container tables not for configuration, with descriptions

Table Name	Description
`last_memcached_signon`	This table is not part of the configuration schema, but is an informative logging table. It records the most recent login time of each memcached server using the configuration. • `ndb_node_id` is an int recording the API node id of the server • `hostname` is the hostname of the memcached server • `server_role` is the role assigned to the server at signon time • `signon_time` is a timestamp recording the memcached startup time In the case of online reconfiguration, signon_time records the time of the latest reconfiguration, not the time of startup. This is an unintended consequence and might be considered a bug.
`demo_table`	demo_table is the container table used with default key prefix in the default server role. It is used to demonstrate SET and GET operations as well as INCR, DECR, and CAS, with one key column and one value column.
`demo_table_tabs`	demo_table_tabs is the container table for the "demo_tabs" container, which is used with the key prefix "t:" in the default server role. It is used to demonstrate one key column with multiple value columns. In memcache operations, the value columns are represented as a tab-separated list of values.

Predefined configuration objects

Predefined clusters. A single ndb_cluster record is predefined, referring to the primary cluster (the one where configuration data is stored) as cluster id 0. Id 0 should always be reserved for the primary cluster.

Predefined cache policies

- "memcache-only" : a policy in which all memcache operations are to use local cache only
- "ndb-only" : a policy in which all memcache operations use the NDB Cluster database, except for FLUSH_ALL, which is disabled
- "caching" : a policy with get_policy, set_policy, and delete_policy all set to "caching". FLUSH_ALL is disabled.

- "caching-with-local-deletes": a policy in which get_policy and set_policy are set to caching, but delete_policy is set to "cache-only", and FLUSH_ALL is disabled.
- "ndb-read-only": a policy in which get_policy is set to ndb_only, so that memcache GET operations use the database, but all other memcache operations are disabled
- "ndb-test": a policy like "ndb-only" with the difference that FLUSH_ALL is allowed (flush_from_db) is true. This is the only predefined policy with flush_from_db enabled. This policy is enabled by default for the default server role, so taht the entire memcache command set can be demonstrated.

Predefined containers

- "demo_table": a container using the table ndbmemcache.demo_table as a container table
- "demo_tabs": a container using the table ndbmemcache.demo_table_tabs as a container table

Predefined memcache server roles and their key prefixes

- "default_role" (role id 0)

  "": The empty (default) prefix uses the ndb-test policy and the demo_table container

  "mc:" Memcache keys beginning with "mc:" are treated according to the memcache-only cache policy

  "t:" Memcache keys beginning with "t:" use the ndb-test cache policy and the demo_tabs container
- The "db-only" role (role id 1)

  "": the empty (default) prefix uses the ndb-only role and demo_table container

  The "t:" prefix uses the ndb-only role and demo_tabs container
- The "mc-only" role (role id 2)

  "": The empty (default) prefix uses local caching only for all keys
- The "ndb-caching" role (role id 3)

  "": The empty (default) prefix uses the "caching" cache policy and "demo_table" container for all keys

Configuration versioning and upgrade.
The configuration schema is versioned, and the version number is stored in the ndbmemcache.meta table. The NDB Engine begins the configuration process by reading the schema version number from this table. As a rule, newer versions of the NDB engine will remain compatible with older versions of the configuration schema.

STABILITY NOTE: consider this section "unstable" & subject to change

Performance Tuning.
Two parameters are used to tune performance of the NDB memcache engine. The parameters are stored in the configuration schema: the "usec_rtt" value of a particular cluster, and the "max_tps" value of a memcache server role. These values are currently used in two ways: to configure the number of connections to each cluster, and to configure a particular fixed number of concurrent operations supported from each connection.

Autotuning. Autotuning uses an estimated round trip time between cluster data nodes and a target rate of throughput to determine the ideal number of cluster connections and transactions per connection for a given workload. Autotuning parameters are described in the next few paragraphs.

- `usec_rtt`: The round trip time, in microseconds, between cluster nodes. The default value is 250, which is typical for an NDB Cluster on a local switched ethernet. To represent a cluster with higher inter-node latency (wider area), a higher value should be used.

- `max_tps`: The desired throughput from a server. This value is a heuristic, and does not in any way express either a floor or a ceiling on the actual throughput obtained. The default value (100000) is reasonable in most cases.

These values are used, as described in the next few paragraphs, to calculate an optimum number of cluster connections with a given transactions-per-second capacity..

Number of cluster connections. The NDB Engine scheduler attempts to open 1 cluster connection per 50000 transactions per second (TPS). This behavior can be overridden by using a scheduler configuration string (see Section 6.4, "NDB Engine Configuration".) If the scheduler fails to open a second or subsequent connection to a cluster—for example, because a node id is not available—this is not a fatal error; it will run with only the connections actually opened.

Number of transactions per connection. We assume that a transaction takes 5 times the cluster round trip time to complete. We can obtain the total number of in-flight transactions by dividing the server's `max_tps` by `5 * rtt` (in seconds). These in-flight transaction objects are evenly distributed among the cluster connections.

Tuning example. The following example starts with the default values `usec_rtt` = 250 and `max_tps` = 100000, and assumes a memcached server with 4 worker threads.

- 100000 TPS divided by 50000 is 2, and the server opens two NDB cluster connections.
- Transaction time in microseconds = 250 µs round trip time * 5 round trips = 1250 µs.
- Transactions per connection per second = 1000000 / tx_time_in_µsec = 1000000 / 1250 = 800.
- Total Ndb objects = max_tps / tx_per_ndb_per_sec = 100000 / 800 = 125.
- 125 Ndb objects / 2 connections = 63 Ndb objects per connection (rounding upward).
- (Rounding upward once more) each of 4 worker threads gets 32 Ndb objects

Online reconfiguration.
It is possible to reconfigure the key-prefix mappings of a running NDB engine without restarting it. This is done by committing a change to the configuration schema, and then updating the `update_timestamp` column of a particular server role in the memcache server roles table. The updating of the timestamp causes an event trigger to fire, so that the memcache server receives notification of the event.

Online reconfiguration can be disabled by using the `-e reconf=false` option on the command line.

Online reconfiguration can be used to connect to new clusters and to create new key-prefix mappings. However, it cannot be used to reset autotuning values on existing connections.

Online reconfiguration is a risky operation that could result in memcache server crashes or data corruption, and is used extensively in the mysql test suite. However, it is not recommended for reconfiguring a production server under load.

The `stats reconf` command can be run before and after online reconfiguration to verify that the version number of the running configuration has increased. Verification of reconfiguration is also written into the memcached log file.

6.5 Memcache protocol commands

The NDB engine supports the complete set of memcache protocol commands. When a newly installed server is started with the default server role and configuration schema, you should be able to run `memcapable`, a memcache-server verification tool, and see all tests pass. After a configuration has been customized, however—for instance, by disabling the FLUSH_ALL command—some `memcapable` tests are expected to fail.

GET, SET, ADD, REPLACE, and DELETE operations. Each of these operations is always performed according to a cache policy associated with the memcache key prefix. It may operate on a locally cached item, an item stored in the database, or both. If an operation has been disabled for the prefix, the developer should be sure to test the disabled operation, since it may fail silently, or with a misleading response code.

CAS. *CAS*, in the memcache protocol, refers to a “compare and set” value, which is used as a sort of version number on a cached value, and enables some optimistic application behavior

If a container includes a CAS column, the ndb engine will generate a unique CAS ID every time it writes a data value, and store it in the CAS column.

Some memcache operations include CAS checks, such as the ASCII CAS update which has the semantics “update this value, but only if its CAS id matches the CAS id in the request”. These operations are supported by the NDB engine. The check of the stored CAS ID against the application's CAS ID is performed in an atomic operation on the NDB data node. This allows CAS checks to work correctly even when multiple memcached servers access the same key-value pair.

If CAS ID checks are in use, and additional NDB Cluster APIs other than memcached are being used to manipulate the data, then the applications using those APIs are responsible for invalidating the stored CAS IDs whenever they update data. They can do this by setting the stored CAS ID value to 0 or `NULL`.

The CAS ID is generated using a scheme that attempts to prevent different servers from generating overlapping IDs. This scheme can be considered a best effort, but not a guarantee, of uniqueness. The scheme constructs an initial CAS as follows:

Part of the 32-bit Cluster GCI from the primary cluster at memcached startup time is used for the high-order bits of the 64-bit CAS ID

Part of the unique cluster node id in the primary cluster used when fetching configuration is used for middle-order bits of the CAS ID

An incrementing counter in the low-order bits of the CAS ID is at least 28-bits wide.

While the NDB engine generates one sequence of CAS IDs, the default engine—used for caching values in local memcached servers—generates a different sequence. Not all combinations of CAS behavior and cache policies have been tested, so any application developer wishing to use CAS should thoroughly test whether a particular configuration behaves as desired.

FLUSH_ALL. FLUSH_ALL is implemented as follows: First, the NDB engine iterates over all configured key-prefixes. For any prefix whose cache policy enables a database flush (`flush_from_db` is `true`), it performs a scanning delete of every row in that prefix's container table. Other prefixes are ignored. This can be a slow operation if the table is large, and some memcache clients may time out before the `DELETE` operation is complete. After all database deletes are complete, the `FLUSH_ALL` command is forwarded to the standard caching engine, which sets a flag invalidating all cached data.

INCR and DECR. All `INCR` and `DECR` operations are pushed down to the NDB data nodes and performed atomically there. This allows multiple memcached servers to increment or decrement the same key and be guaranteed a unique value each time.

The `INCR` and `DECR` operations have clearer and more useful semantics in the binary memcache protocol than in the ASCII protocol. The binary protocol is recommended.

The memcached ASCII protocol introduces some ambiguities in the handling of `INCR` and `DECR`, and forces the NDB engine to work in `dup_numbers` mode, in which the `value_column` and the `math_column` must mirror each other.

`dup_numbers` mode is enabled for key prefixes that meet all of the following conditions:

- The container includes a math column, AND
- The container includes a single value column, AND
- The data type of the value column is non-numeric

In `dup_numbers` mode, the following special behavior applies:

- Whenever an ASCII `SET`, `ADD`, or `REPLACE` command sets a value that could be interpreted as numeric, and the container defines a math_column, then the text value is stored in the value column and the numeric value is also stored in the math column.
- Whenever an ASCII `INCR` or `DECR` command is performed, the text value in that container's value column is set to `NULL`.
- Whenever a memcached `GET` command is issued, and the container's value column is `NULL`, but the container's math column is not `NULL`, then the math value is returned to the client.

APPEND and PREPEND. The memcache `APPEND` and `PREPEND` operations are implemented as a single transaction which involves a read of the existing value with an exclusive lock, followed by a write of the new value. The read and write are grouped atomically into a transaction, but unlike `INCR` and `DECR`, which can run natively on the data nodes, `APPEND` and `PREPEND` are executed inside the memcached server. This means that multiple memcached servers can contend to `APPEND` and `PREPEND` the same value, and that no updates will be lost, but this contention relies on locking behavior that could cause noticably increased latency.

STATS. A memcached server can provide many sets of statistics; use `STATS` *`KEYWORD`* from a login shell.

All statistics usually available from the memcached 1.6 core and the default engine are available. For instance, `STATS`, `STATS SLABS`, and `STATS SETTINGS` are all currently supported as described in the memcached documentation. Some special sets of statistics are available from the `NDB` engine, using the `STATS` commands described in the following list:

- `STATS NDB`: Returns NDB API statistics for each NDB cluster connection. These are the same internal statistics which are available as system status variables from the MySQL Server. See NDB API Statistics Counters and Variables, for more information.
- `STATS SCHEDULER`: Returns statistics for the S scheduler. All of these statistics are reported on the cluster connection level.
  - `cl%d.conn%d.sent_operations`: Records the number of operations sent from the connection's send thread to the cluster data nodes.
  - `cl%d.conn%d.batches`: Records the number of operation batches sent from the send thread to the data nodes. Each batch contains one or more operations. `sent_operations` / `batches` can be used to compute the average batch size.
  - `cl%d.conn%d.timeout_races`: This records a rare race condition that may occur in the send thread. It is expected to be 0, or to be a very low number compared to sent_operations.
- `stats reconf`: If the `NDB` engine is currently loading a new configuration, command returns the single-line message `Loading` *`revno`*, where *`revno`* is the version number of the configuration being loaded.

  Otherwise, this command returns the statistical message `Running` *`revno`*.

  `revno` starts at 1 when the memcached server begins running, and is incremented by 1 for each online reconfiguration.

6.6 The memcached log file

Whenever the `NDB` memcache engine is initialized, it writes a message including a timestamp and version number to its log file, as shown here:

```
12-Oct-2011 13:40:00 PDT NDB Memcache 8.0.20-ndb-8.0.20 started
[NDB 8.0.20; MySQL 8.0.20-ndb-8.0.20]
```

It also logs its attempt to connect to a primary cluster:

```
Contacting primary management server (localhost:1186) ...
·Connected to "localhost:1186" as node id 4.
```

Upon successfully fetching initial configuration data, the memcache engine logs a summary message describing the configuration similar to what is shown here:

```
Retrieved 3 key prefixes for server role "default_role"
The default behavior is that:
 GET uses NDB only
 SET uses NDB only
 DELETE uses NDB only
The 2 explicitly defined key prefixes are "mc:" () and "t:" (demo_table_tabs)
Server started with 4 threads.
```

The memcache engine also logs the establishment of each additional cluster connection, as shown here:

```
Connected to "" as node id 5.
```

A `priming the pump...` message indicates that the engine is about to prefetch a pool of transaction objects (API Connect Records). It is followed by a `done ...` message indicating how much time was used by prefetching. The server is not ready to respond to clients until after the prefetching is completed.

```
Priming the pump ...
Scheduler: using 2 connections to cluster 0
Scheduler: starting for 1 cluster; c0,f0,t1
done [0.579 sec].
```

Once the NDB engine has finished initializing, memcached prints a message verifying that the engine was loaded, and enumerating some of its features:

```
Loaded engine: NDB Memcache 8.0.20-ndb-8.0.20
Supplying the following features: compare and swap, persistent storage, LRU
```

If online reconfiguration is enabled, the NDB engine logs each reconfiguration, along with a summary of the new configuration, similar to what is shown here:

```
Received update to server role default_role
Retrieved 3 key prefixes for server role "default_role".
The default behavior is that:
 GET uses NDB only
 SET uses NDB only
 DELETE uses NDB only.
The 2 explicitly defined key prefixes are "mc:" () and "t:" (demo_table_tabs)
ONLINE RECONFIGURATION COMPLETE
```

On shutdown, memcached logs the shutdown sequence'a initialization and completion, and the NDB engine's scheduler logs its own shutdown as well:

```
Initiating shutdown
Shutting down scheduler.
Shutdown completed.
```

6.7 Known Issues and Limitations of ndbmemcache

This section provides information about known issues with and design limitations of the Memcache API for NDB Cluster.

Problems with AUTO_INCREMENT. ndbmemcache bypasses the `NDB` storage engine's mechanism for handling `AUTO_INCREMENT` columns. This means that, when you insert rows using ndbmemcache into a table having an `AUTO_INCREMENT` column, this column is not automatically updated. This can lead to duplicate key errors when inserts are performed later using SQL in a MySQL client application such as `mysql`.

To work around this issue, you can employ a sequence generator as described here.

Online schema changes not supported. The memcached daemon does not detect online schema changes; after making such changes, you must restart the memcached daemon before the updated schema can be used by your application.

Fractional seconds. ndbmemcache supports the use of fractional seconds with the `TIME`, `DATE`, and `DATETIME` data types as implemented in MySQL 5.6.4 and later.

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