



Firebird 3.0 Release Notes

Helen Borrie (Collator/Editor)

22 November 2014 - Document v.0300-15 - for Firebird 3.0 Beta 1

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Chapter 1

General Notes

Thank you for trying out this first Beta release of the forthcoming Firebird 3.0. We cordially invite you to test it hard against your expectations and engage with us in identifying and fixing any bugs you might encounter.

Bug Reporting

- If you think you have discovered a new bug in this release, please make a point of reading the instructions for bug reporting in the article [How to Report Bugs Effectively](#), at the Firebird Project website.
- If you think a bug fix hasn't worked, or has caused a regression, please locate the original bug report in the Tracker, reopen it if necessary, and follow the instructions below.

Follow these guidelines as you attempt to analyse your bug:

1. Write detailed bug reports, supplying the exact build number of your Firebird kit. Also provide details of the OS platform. Include reproducible test data in your report and post it to our [Tracker](#).
2. You are warmly encouraged to make yourself known as a field-tester of this pre-release by subscribing to the [field-testers' list](#) and posting the best possible bug description you can.
3. If you want to start a discussion thread about a bug or an implementation, please do so by subscribing to the [firebird-devel list](#). In that forum you might also see feedback about any tracker ticket you post regarding this Beta.

Documentation

You will find all of the README documents referred to in these notes—as well as many others not referred to—in the doc sub-directory of your Firebird 3.0 installation.

--The Firebird Project

Chapter 2

New In Firebird 3.0

The primary goals for Firebird 3 were to unify the server architecture and to improve support for SMP and multiple-core hardware platforms. Parallel objectives were to improve threading of engine processes and the options for sharing page cache across thread and connection boundaries.

Alongside these aims came new strategies to improve performance, query optimization, monitoring and scalability and to address the demand for more security options. A number of popular features were introduced into the SQL language, including the long-awaited support for the Boolean data type and the associated logical predications.

Summary of Features

The following list summarises the features and changes, with links to the chapters and topics where more detailed information can be found.

Unification of the Firebird executable is complete

With the completion of true SMP support for Superserver, the Firebird core is now a unified library that supports a single ODS, loadable either as an embedded engine or by the “network listener” executable. Choice of server model is determined by settings for two new configuration parameters defining the locking and cache models, respectively: `SharedDatabase` and `SharedCache`. They can be specified at either global level (in `firebird.conf`) or “per database” (in `databases.conf`).

By default, `SharedDatabase = false` and `SharedCache = true`, thus meaning SuperServer.

Note

The previous `aliases.conf` is replaced by `databases.conf`, now including not just aliases for databases but also (optionally) configuration parameters to enable configuration of databases and/or alternative security databases individually.

The changes are described in more detail in the chapter [Changes in the Firebird Engine](#).

True SMP support for SuperServer

In Superserver mode, the engine now makes use of multiple CPUs and cores when spawning connections.

Tracker: [CORE-775](#)

Implemented by V. Khorsun

New, object-oriented C++ APIs

Object-oriented C++ APIs enable external code routines to plug in and run safely inside Firebird engine space, including (but not limited to):

- Encryption schemes for data
- User authentication schemes, including secure key exchange

- Eventually, plug-in support for stored procedures, triggers and functions written in Java, C++, Object-Pascal, etc.

“Per-Database” Configuration

[Custom configuration at database level](#) can now be achieved with formal entries in `databases.conf` (formerly `aliases.conf`).

Multiple Security Databases

Firebird now supports user access control via more than one security database on the server. Each database can be [configured](#), using the parameter **SecurityDatabase** in `databases.conf`, to use a specific database other than the default `security3.fdb`.

Several New SQL Commands to Manage Users and Access

Changes in architecture, stiffening of rules for security and data integrity, along with feature requests, have given rise to a raft of new [SQL commands for managing users and their access to objects](#).

New Data Type Support

A true BOOLEAN type (True/False/Unknown), complete with support for logical predicates, e.g.,

```
UPDATE ATABLE
  SET MYBOOL = (COLUMN1 IS DISTINCT FROM COLUMN2)
```

For details, see [BOOLEAN Type](#).

IDENTITY type, spawning unique identifiers for the defined column from an internal generator. For details, see [IDENTITY-Style Column](#).

Support for SQL Packages

For details, refer to [Packages](#).

DDL Triggers

Now, triggers can be written to execute when database objects are modified or deleted. A typical use is to block unauthorised users from performing these tasks.

For details, refer to [DDL Triggers](#).

'Window' functions in DML

A whole new series of analytical functions to work with multiple subsets in DML. See [Window \(Analytical\) Functions](#).

Chapter 3

Changes in the Firebird Engine

In Firebird 3, the remodelling of the architecture that was begun in v.2.5 was completed with the implementation of full SMP support for the Superserver model. In the new scheme, it is possible to configure the execution model individually per database.

Remodelled Architecture

Dmitry Yemanov

The remodelled architecture integrates the core engine for Classic/Superclassic, Superserver and embedded models in a common binary. The cache and lock behaviours that distinguish the execution models are now determined externally by the settings in two new configuration parameters: **SharedDatabase** and **SharedCache** and the connection method in the parameter **Providers**. The parameters for configuring the architecture are specified globally (in `firebird.conf`) and can be overridden specifically for a database (in `databases.conf`).

Note

`databases.conf` is the old `aliases.conf` with a new name. In Firebird 3, the role of this file involves (potentially) much more than being just a lookup for database file paths. For more details about this, refer to the chapter [Configuration Additions and Changes](#).

Working Modes (“Models”)

Table 3.1. Matrix of Working Modes (D. Yemanov)

	SharedDatabase=0	SharedDatabase=1
SharedCache=0	Single user	Classic, SuperClassic
SharedCache=1	Superserver	See Note

In `firebird.conf` the defaults make `SharedDatabase` false (=0) and `SharedCache` true (=1), i.e., SuperServer.

SharedDatabase=1, SharedCache=1

This mode, although theoretically possible, is not supported currently.

Execution Modes

Classic and SuperClassic

Classic and SuperClassic are set up using the same configuration: `SharedDatabase = true` and `SharedCache = false`.

- On Linux, the server startup method determines which will run, i.e., running *xinetd* means Classic, while running the *firebird* means SuperClassic.
- On Windows, the command line options for *firebird.exe* specify the mode, just as they did in v.2.5 for *fb_inet_server.exe*, i.e., switch *-m* (for multi-threaded) means SuperClassic; otherwise Classic is implied.

Superserver

Superserver is set up using the configuration `SharedDatabase = true` and `SharedCache = true`.

- For multi-user use it is important to start the executable with the *-m* switch. It will start in single-user mode otherwise.

Single-user Mode

`SharedDatabase = false` and `SharedCache = false` means that only one connection is possible, i.e., single user mode.

Whether a “hostless” connection is handled by the embedded engine or by the network listener (e.g. the XNET case), the settings `SharedDatabase` and `SharedCache` define the behaviour at the engine level. For an embedded connection, `SharedDatabase = false` and `SharedCache = true` would mean the pre-v.2.5 embedded behaviour on Windows (based on Superserver), while `SharedDatabase = true` and `SharedCache = false` would mean the v.2.5 embedded behaviour (based on SuperClassic).

How the connection string is processed depends on order specified in the Providers setting. The default setting is `Remote`, `Engine12`, `Loopback`. Connection strings to hosts are handled by the **Remote** provider, while “hostless” ones are handled, in turn, by **Engine12** or **Loopback**.

Accordingly, if `libEngine12.so` or `engine12.dll` (as appropriate to platform) is available to the Dispatcher (**y-valve**), a “hostless” connection will be handled by the embedded engine; otherwise it will be handled by the loopback provider (XNET on Windows, TCP via localhost on POSIX).

Note

Of course, technically, XNET is not a local loopback provider (a local connection through a remote interface) and, in previous Firebird versions, it was treated as being in the “remote” space. On Firebird 3, it belongs with the local loopback providers.

Providers

The providers are more or less what we traditionally thought of as the methods used to connect a client to a server, that is to say, across a network, host-locally, via the local loopback (“localhost”) or by a more direct local connection (the old `libfbembedded.so` on POSIX, now implemented as the plug-in library `libEngine12.so`; on Windows, `engine12.dll`; on MacOSX, `engine12.dylib`).

In `firebird.conf`, all are available by default, as follows,

```
#Providers = Remote,Engine12,Loopback
```

Note

In `databases.conf`, one or more providers can be blocked by pasting the uncommented line and deleting the unwanted provider[s].

The Providers Architecture

Alex Peshkov

Although a key feature of Firebird 3, the Providers architecture is not new. Providers existed historically in Firebird's predecessors and, though well hidden, are present in all previous versions of Firebird. They were introduced originally to deal with a task that has been performed since then by “interface layers” such as ODBC, ADO, BDE and the like, to enable access to different database engines using a single external interface.

Subsequently, this Providers architecture (known then as Open Systems Relational Interface, OSRI) also showed itself as very efficient for supporting a mix of old and new database formats—different major on-disk structure versions—on a single server having mixed connections to local and remote databases.

The providers implemented in Firebird 3 make it possible to support all these modes (remote connections, databases with differing ODS, foreign engines) as well as *chaining* providers. Chaining is a term for a situation where a provider is using a callback to the standard API when performing an operation on a database.

The Components

The main element of the Providers architecture is the **y-valve**. On the initial `attach` or `create database` call **y-valve** scans the list of known providers and calls them one by one until one of them completes the requested operation successfully. For a connection that is already established, the appropriate provider is called at once with almost zero overhead.

Let's take a look at some samples of **y-valve** operation when it selects the appropriate provider at the `attach` stage. These use the default configuration, which contains three providers:

- **Remote** (establish network connection)
- **Engine12** (main database engine)
- **Loopback** (force network connection to the local server for <database name> without an explicit network protocol being supplied).

The typical client configuration works this way: when one attaches to a database called `RemoteHost:dbname` (TCP syntax) or `\\RemoteHost\dbname` (NetBios) the **Remote** provider detects explicit network protocol syntax and, finding it first in the Provider list, redirects the call to `RemoteHost`.

When <database name> does not contain a network protocol but just the database name, the **Remote** provider rejects it and the **Engine12** provider comes to the fore and tries to open the named database file. If it succeeds, we get an embedded connection to the database.

Note

A special “embedded library” is no longer required. To make the embedded connection, the standard client loads the appropriate provider and becomes an embedded server.

Failure Response

But what happens if the engine returns an error on an attempt to attach to a database?

- If the database file to be attached to does not exist there is no interest at all.
- An embedded connection may fail if the user attaching to it does not have enough rights to open the database file. That would be the normal case if the database was not created by that user in embedded mode or if he was not explicitly given OS rights for embedded access to databases on that box.

Note

Setting access rights in such a manner is a requirement for correct Superserver operation.

- After a failure of **Engine12** to access the database, the **Loopback** provider is attempted for an attach. It is not very different to **Remote** except that it tries to access the named database <dbname> on a server running a TCP/IP local loopback.

On Windows, the XNET protocol (also known as “Windows local connection”) is used for it. POSIX systems prepend <dbname> with `localhost:` and use a TCP connection.

If the attachment succeeds, a remote-like connection is established with the database even though it is located on the local machine.

Other Providers

Use of providers is not limited to the three standard ones. Firebird 3 does not support pre-ODS 12 databases but Firebird 3 will have an additional provider to access older databases (ODS 8 to 11.x). Removing support for old formats from the engine helps to simplify its code and gain a little speed. Taking into account that this speed gain sometimes takes place in performance-critical places, like searching a key in an index block, avoiding old code and related branches really does make Firebird fly faster.

Nevertheless, the Providers architecture does make it possible to access old databases when changing to a higher version of Firebird.

Custom Providers

A strong feature of the Providers architecture is ability for the deployer to add his own providers to the server, the client, or both.

So what else might be wanted on a client, other than a remote connection? Recall *Provider chaining* that was mentioned earlier. Imagine a case where a database is accessed via very slow network connection, say something like 3G or, worse, GPRS. What comes to mind as a way to speed it up is to cache on the client some big tables that rarely change. Such systems were actually implemented but, to do it, one had to rename `fbclient` to something arbitrary and load it into its own library called `fbclient`, thus making it possible to use standard tools to access the database at the same time as caching required tables. It works but, as a solution, it is clearly not ideal.

With the Providers architecture, instead of renaming libraries, one just adds a local caching provider which can use any method to detect connections to it (something like a `cache@` prefix at the beginning of the database name, or whatever else you choose).

In this example, when the database name `cache@RemoteHost:dbname` is used, the caching provider accepts the connection and invokes the **y-valve** once more with the traditional database name `RemoteHost:dbname`. When the user later performs any call to his database, the caching provider gets control of it before **Remote** does and, for a locally cached table, can avoid making calls to the remote server.

Use of chaining allows a lot of other useful things to be implemented, such as database replication without the need for triggers: just repeat the same calls for the replication host when, for example, a transaction is committed. In this case, the chaining provider is installed on the server, not the client, and no modification of the command line is needed at all.

To avoid cycling when performing a callback to **y-valve** at attach time, such a provider can modify the list of providers using the `isc_dpb_config` parameter in the DPB. The same technique may be used at the client, too.

For details, see the [Configuration Additions and Changes](#) chapter.

The ability to access foreign database engines using providers should not be overlooked, either. It might seem strange to consider this, given the number of tools available for this sort of task. Think about the ability to access other Firebird databases using EXECUTE STATEMENT, that became available in Firebird 2.5. With a provider to ODBC or other common tool to access various data sources it is within reach to use EXECUTE STATEMENT to get direct access from procedures and triggers, to data from any database having a driver for the chosen access tool. It is even possible to have a provider to access some particular type of foreign database engine if there is some reason to want to avoid the ODBC layer.

Providers Q & A

Q. Interfaces and providers are probably very good, but I have an old task written using plain API functions and for a lot of reasons I can't rewrite it in the near future. Does it mean I will have problems migrating to Firebird 3?

- A. Definitely no problems. The old API is supported for backward compatibility in Firebird 3 and will be supported in future versions as long as people need it.

And what about performance when using the old API?

- A. The functional API is implemented as a very thin layer over interfaces. Code in most cases is trivial: convert passed handles to pointers to interfaces—hitherto referred to as “handle validation”—and invoke the appropriate function from the interface.

Functions that execute an SQL operation and fetch data from it are one place where coding is a little more complex, involving the SQLDA construct. The data moves related to the SQLDA have always created an overhead. The logic between the new and old APIs does not add significantly to that old overhead.

Plug-Ins

Alex Peshkov

From version 3 onward, Firebird's architecture supports plug-ins. For a number of predefined points in the Firebird code, a developer can write his own fragment of code for execution when needed.

A plug-in is not necessarily one written by a third party: Firebird has a number of intrinsic plug-ins. Even some core parts of Firebird are implemented as plug-ins.

What is a Plug-In?

The term “plug-in” is used to name related but different things:

- a dynamic library, containing code to be loaded as a plug-in (often called a *plug-in module*) and stored in the `$FIREBIRD/plugins` directory;
- code *implementing* a plug-in. That is slightly different from the *library*, since a single dynamic library may contain code for more than one plug-in;
- a plug-in's *factory*: an object created by that code (pure virtual C++ class), creating instances of the plug-in at Firebird's request;
- an *instance* of the plug-in, created by its factory.

Plug-In Types

Firebird's plug-in architecture makes it possible to create plug-ins of predefined types. Each version of Firebird will have a fixed set of supported plug-in types. To add a further type, the first requirement is to modify the Firebird code. Our plug-in architecture facilitates both adding new types of plug-ins and simplifying the coding of the plug-in along generic lines.

To be able to implement a plug-in, say, for encrypting a database on the disk, the Firebird code has to be prepared for it: it must have a point from which the plug-in is called.

The set of plug-in types implemented in Firebird 3 comprises:

user authentication related:

- AuthServer (validates user's credentials on server when logins are used)
- AuthClient (prepares credentials to be passed over the wire)
- AuthUserManagement (maintains a list of users on a server in a format known to AuthServer)

ExternalEngine

Controls the use of various engines, see [External Engines](#).

Trace

The Trace plug-in was introduced in Firebird 2.5, but the way it interacts with the engine was changed in Firebird 3 to accord with the new generic rules.

Encryption

encrypting plug-ins are for

- network (WireCrypt)
- disk (DbCrypt)
- a helper plug-in (KeyHolder), used to help maintain the secret key(s) for DbCrypt

Provider

Firebird 3 supports [providers](#) as a plug-in type.

Technical Details

Plug-ins use a set of special Firebird interfaces. All plug-in-specific interfaces are reference counted, thus putting their lifetime under specific control. Interfaces are declared in the include file `plug-in.h`. `DbCrypt_example` provides a simple model for writing a plug-in module

Note

The example does not perform any actual encryption, it is just a sample of how to write a plug-in. Complete instructions for writing plug-ins are not in scope for this document.

Features of a Plug-In

A short list of plug-in features:

- You can write a plug-in in any language that supports pure virtual interfaces. Interface declarations will need to be written for your language if they are missing.
- As with UDFs, you are free to add any reasonable code to your plug-in—with emphasis on *reasonable*. For example, prompting for user input at the server's console from a plug-in is hardly “reasonable”!
- Calling the Firebird API from your plug-in is OK, if needed. For example, the default authentication server and user manager use a Firebird database to store accounts.
- Firebird provides a set of interfaces to help with configuring your plug-ins. It is not obligatory to use them, since the plug-in code is generic and can employ any useful method for capturing configuration information. However, using the standard tools provides commonality with the established configuration style and should save the additional effort of rolling your own and documenting it separately.

Configuring Plug-ins

Configuration of plug-ins has two parts:

1. The engine has to be instructed what plug-ins it should load
2. The plug-ins themselves sometimes need some configuration.

The plug-ins to be loaded for each type of plug-in are defined in the main configuration file, `firebird.conf`, usually with defaults. The ones defined in Firebird 3 are discussed in the chapter entitled “[Configuration Additions and Changes](#)”. In summary, the set that provides normal operation in the server, client and embedded cases consists of:

- `AuthServer = Srp, Win_Sspi`
- `AuthClient = Srp, Win_Sspi, Legacy_Auth`
- `UserManager = Srp`
- `TracePlugin = fbtrace`
- `Providers = Remote,Engine12,Loopback`

- WireCryptPlugin = Arc4

Note

If you want to add other plug-ins, they must be cited in `firebird.conf`. Apart from other considerations, this requirement acts as a security measure to avoid loading unknown code.

Taking the entry **TracePlugin = fbtrace** as an example, what does the value **fbtrace** signify? In a trivial case, it can indicate the name of a dynamic library but the precise answer is more complicated.

As mentioned earlier, a single plug-in module may implement more than one plug-in. In addition, a single plug-in may have more than one configuration at once, with a separate plug-in factory created for each configuration. Each of these three object contexts (module | implementation | factory) has its own name:

- The name of a module is the file name of a dynamic library
- The name of a plug-in implementation is the one given to it by the developer of the plug-in. It is hard-coded inside the module.
- The name of a factory is, by default, the same as the name of the plug-in implementation's name. It is the factory name which is actually used in `firebird.conf`.

In a typical trivial case, where a module contains one plug-in that works with just one configuration and all three names are equal, and no more configuration is needed. An example would be `libEngine12.so` | `Engine12.dll` | `Engine12.dylib`, that contains the implementation of the embedded provider **Engine12**. Nothing other than the record **Providers = Engine12** is needed to load it.

For something more complex a file will help you to set up the plug-in factories precisely.

plugins.conf

The file `$(root)/plugins.conf` has two types of records: **config** and **plugin**.

the **plugin** record is a set of rules for loading and activating the plug-in. Its format is:

```
Plugin = PlugName ## this is the name to be referenced in firebird.conf
{
  Module = LibName ## name of dynamic library
  RegisterName = RegName ## name given to plug-in by its developer
  Config = ConfName ## name of config record to be used
  ConfigFile = ConfigFile ## name of a file that contains plug-in's configuration
}
```

When plug-in *PlugName* is needed, Firebird loads the library *LibName* and locates the plug-in registered with the name *RegName*. The configuration from the config record *ConfName* or the config file *ConfigFile* are passed to the library.

Note

If both *ConfName* and *ConfigFile* are given, then the config record will be used.

If both parameters are missing, the default *PlugName* is used; **except that** if the **ConfigFile** is present and its name is the same as the module's dynamic library but with a `.conf` extension, it will be used.

The **ConfigFile** is expected to use the format **Key=Value**, in line with other Firebird configuration files.

For the plug-in configuration record the same format is used:

```
Config = ConfName
{
    Key1 = Value1
    Key2 = Value2
    ...
}
```

A Sample Setup

Suppose you have a server for which some clients trust the wire encryption from one vendor and others prefer a different one. They have different licences for the appropriate client components but both vendors use the name “BestCrypt” for their products.

The situation would require renaming the libraries to, say, WC1 and WC2, since there cannot be two files in the same directory with the same name. Now, the modules stop loading automatically because neither is called “BestCrypt” any longer.

To fix the problem, `plug-ins.conf` should contain something like this:

```
Plugin = WC1
{
    RegisterName = BestCrypt
}
Plugin = WC2
{
    RegisterName = BestCrypt
}
```

The module names will be automatically set to WC1 and WC2 and found. You can add any configuration info that the plug-ins need.

Remember to modify `firebird.conf` to enable both plug-ins for the **WireCryptPlugin** parameter:

```
WireCryptPlugin = WC1, WC2
```

The server will now select appropriate plug-in automatically to talk to the client.

Another sample is distributed with Firebird, in `$(root)/plugins.conf`, configuring one of the standard plug-ins, UDR. Because it was written to use non-default configuration, the module name and one configuration parameter are supplied explicitly.

Plug-Ins Q & A

Q. There are plug-ins named Remote, Loopback, Arc4 in the default configuration, but no libraries with such names. How do they work?

- A. They are “built-in” plug-ins, built into `fbclient` library, and thus always present. Their existence is due to the old ability to distribute the Firebird client for Windows as a single dll. The feature is retained for cases where the standard set of plug-ins is used.

Q. What do the names of Srp and Arc4 plug-ins mean?

- A. Srp implements the Secure Remote Passwords protocol, the default way of authenticating users in Firebird 3. Its effective password length is 20 bytes, resistant to most attacks (including “man in the middle”) and works without requiring any key exchange between client and server to work.

Arc4 means Alleged RC4 - an implementation of RC4 cypher. Its advantage is that it can generate a unique, cryptographically strong key on both client and server that is impossible to guess by capturing data transferred over the wire during password validation by SRP.

The key is used after the SRP handshake by Arc4, which makes wire encryption secure without need to exchange any keys between client and server explicitly.

Q. What do Win_Sspi and Legacy_Auth mean?

- A. Windows SSPI has been in use since Firebird 2.1 for Windows trusted user authentication. Legacy_Auth is a compatibility plug-in to enable connection by the Firebird 3 client to older servers. It is enabled by default in the client.

And Yes, it still transfers almost plain passwords over the wire, for compatibility.

On the server it works with a security database from Firebird 2.5, and should be avoided except in situations where you understand well what are you doing.

To use Legacy_Auth on the server you will need to avert network traffic encryption in `firebird.conf` by reducing the default Required setting for the **WireCrypt** parameter, either

```
WireCrypt = Enabled
```

or

```
WireCrypt = Disabled
```

Q. How can I find out what the standard Authentication and User Manager plug-ins are?

- They are listed in `firebird.conf`.

External Engines

Adriano dos Santos Fernandes

The UDR (User Defined Routines) engine adds a layer on top of the FirebirdExternal engine interface with the purpose of

- establishing a way to hook external modules into the server and make them available for use
- creating an API so that external modules can register their available routines
- making instances of routines “per attachment”, rather than dependent on the internal implementation details of the engine

External Names

An external name for the UDR engine is defined as

```
'<module name>!<routine name>!<misc info>'
```

The <module name> is used to locate the library, <routine name> is used to locate the routine registered by the given module, and <misc info> is an optional user-defined string that can be passed to the routine to be read by the user.

Module Availability

Modules available to the UDR engine should be in a directory listed by way of the path attribute of the corresponding plugin_config tag. By default, a UDR module should be on <fbroot>/plugins/udr, in accordance with its path attribute in <fbroot>/plugins/udr_engine.conf.

The user library should include FirebirdUdr.h (or FirebirdUdrCpp.h) and link with the udr_engine library. Routines are easily defined and registered, using some macros, but nothing prevents you from doing things manually.

Note

A sample routine library is implemented in `examples/udr`, showing how to write functions, selectable procedures and triggers. It also shows how to interact with the current attachment through the legacy API.

Scope

The state of a UDR routine (i.e., its member variables) is shared among multiple invocations of the same routine until it is unloaded from the metadata cache. However, it should be noted that the instances are isolated “per session”.

Character Set

By default, UDR routines use the character set that was specified by the client.

Note

In future, routines will be able to modify the character set by overriding the `getCharSet` method. The chosen character set will be valid for communication with the old Firebird client library as well as the communications passed through the FirebirdExternal API.

Enabling UDRs in the Database

Enabling an external routine in the database involves a DDL command to “create” it. Of course, it was already created externally and (we hope) well tested.

Syntax Pattern

```
{ CREATE [ OR ALTER ] | RECREATE | ALTER } PROCEDURE <name>
[ ( <parameter list> ) ]
[ RETURNS ( <parameter list> ) ]
```

```
EXTERNAL NAME '<external name>' ENGINE <engine>

{ CREATE [ OR ALTER ] | RECREATE | ALTER } FUNCTION <name>
  [ <parameter list> ]
  RETURNS <data type>
  EXTERNAL NAME '<external name>' ENGINE <engine>

{ CREATE [ OR ALTER ] | RECREATE | ALTER } TRIGGER <name>
  ...
  EXTERNAL NAME '<external name>' ENGINE <engine>
```

Examples

```
create procedure gen_rows (
  start_n integer not null,
  end_n integer not null
) returns (
  n integer not null
) external name 'udrcpp_example!gen_rows'
  engine udr;

create function wait_event (
  event_name varchar(31) character set ascii
) returns integer
  external name 'udrcpp_example!wait_event'
  engine udr;

create trigger persons_replicate
  after insert on persons
  external name 'udrcpp_example!replicate!ds1'
  engine udr;
```

How it Works

The external names are opaque strings to Firebird. They are recognized by specific external engines. External engines are declared in configuration files, possibly in the same file as a plug-in, as in the sample UDR library that is implemented in `$(root)/plugins`.

```
external_engine = UDR {
  plugin_module = UDR_engine
}

plugin_module = UDR_engine {
  filename = $(this)/udr_engine
  plugin_config = UDR_config
}

plugin_config = UDR_config {
  path = $(this)/udr
}
```

When Firebird wants to load an external routine (function, procedure or trigger) into its metadata cache, it gets the external engine through the plug-in external engine factory and asks it for the routine. The plug-in used is the one referenced by the attribute **plugin_module** of the external engine.

Note

Depending on the server architecture (Superserver, Classic, etc) and implementation details, Firebird may get external engine instances “per database” or “per connection”. Currently, it always gets instances “per database”.

Optimizer Improvements

Dmitry Yemanov

- See Tracker item [CORE-4528](#).

Hash/merge joins for non-field (DBKEY or derived expression) equalities are now allowed.

- See Tracker item [CORE-1482](#).

The optimizer now considers the ORDER BY optimization when making its decision about join order.

Other Optimizations

Vlad Khorsun

- See Tracker item [CORE-4556](#).

Data pages are now allocated as a group of sequential ordered pages (extents).

- See Tracker item [CORE-4445](#).

The main database file extends faster when physical backup state changes from *stalled* to *merge*.

- See Tracker item [CORE-4443](#).

Linux systems that support “fast file growth” can now use it.

- See Tracker item [CORE-4432](#).

Attachments no longer block others when the allocation table is read for the first time.

- See Tracker item [CORE-4431](#).

Contention has been reduced for the allocation table lock while database is in *stalled* physical backup state.

Remote Interface/Network Protocol

Dmitry Yemanov

Tracker item [CORE-2530](#).

Further improvements were made to Firebird's network protocol, providing a denser data stream and better prefetch logic. The following improvements were implemented:

1. The full length of a field whose value is NULL is no longer sent over the wire. (Tracker item [CORE-2897](#)). NULL flags (4 bytes per field) are replaced with a bitmap and only these flags are transmitted, in the bitmap.

This improvement is available for the DSQL API only, so *gbak* does not benefit from this improvement, as it uses a lower level BLR API.

2. The prefetch (batch receive) algorithm is now aware of variable-length messages, so that VARCHARs and NULLs may reduce the transmitted message size, allowing more rows to be transmitted in each batch.

Acknowledgement

This work was sponsored by donations collected at the 9th Firebird Developers' Day conference in Brazil.

Miscellaneous Improvements

Miscellaneous engine improvements include.-

Connections Limit Raised

Paul Beach

([CORE-4439](#)) :: Maximum connections (FD_SETSIZE) on Windows Superserver and Superclassic was raised from 1024 to 2048.

Better Error Diagnosis

Dmitry Yemanov

([CORE-3881](#)) :: The error reported for index/constraint violations has been extended to include the problematic key value.

ICU Version Upgraded

Adriano dos Santos Fernandes

([CORE-2224](#)) :: The ICU version was upgraded to v.52.1.

Internal Debug Info Made Human-readable

Vlad Khorsun

A new BLOB filter translates internal debug information into text.

A Silly Message is Replaced

Claudio Valderrama C.

A silly message sent by the parser when a reference to an undefined object was encountered was replaced with one that tells it like it really is.

New Pseudocolumn RDB\$RECORD_VERSION

Adriano dos Santos Fernandes

A pseudocolumn named RDB\$RECORD_VERSION returns the number of the transaction that created the current record version.

It is retrieved the same way as RDB\$DB_KEY, i.e., **select RDB\$RECORD_VERSION from aTable where...**

systemd init Scripts

Alex Peshkov

systemd init scripts are available in Firebird 3 POSIX installers. See Tracker ticket [CORE-4085](#).

Chapter 4

Changes to the Firebird API and ODS

ODS (On-Disk Structure) Changes

New ODS Number

Firebird 3.0 creates databases with an ODS (On-Disk Structure) version of 12.

Implementation ID is Deprecated

Alex Peshkov

The Implementation ID in the ODS of a database is deprecated in favour of a new field in database headers describing hardware details that need to match in order for the database to be assumed to have been created by a compatible implementation.

The old Implementation ID is replaced with a 4-byte structure consisting of hardware ID, operating system ID, compiler ID and compatibility flags. The three ID fields are just for information: the ODS does not depend upon them directly and they are not checked when opening the database.

The compatibility flags *are checked* for a match between the database and the engine opening it. Currently we have only one flag, for endianness. As previously, Firebird will not open a database on little-endian that was created on big-endian, nor vice versa.

Sample gstat Output

```
# ./gstat -h employee
Database "/usr/home/firebird/trunk/gen/Debug/firebird/examples/empbuild/employee.fdb"
Database header page information:
.....
Implementation                HW=AMD/Intel/x64 little-endian OS=Linux CC=gcc
.....
```

The purpose is to make it easier to do ports of Firebird for new platforms.

Maximum Page Size

The maximum page size remains 16 KB (16384 bytes).

Maximum Number of Page Buffers in Cache

The maximum number of pages that can be configured for the database cache depends on whether the database is running under 64-bit or 32-bit Firebird:

- 64-bit :: $2^{31} - 1$ (2,147,483,647) pages
- 32-bit :: 128,000 pages, i.e., unchanged from V.2.5

System Tables

New System Tables

RDB\$MAPPING	Stores authentication and other security mappings
RDB\$PACKAGES	Header for SQL packages
SEC\$USERS	Virtual table to query the local user list
SEC\$USER_ATTRIBUTES	Virtual table storing local user attributes

Changes to System Tables

RDB\$SYSTEM_FLAG

Claudio Valderrama C.

RDB\$SYSTEM_FLAG has been made NOT NULL in all tables.

[CORE-2787](#).

RDB\$TYPES

Dmitry Yemanov

Missing entries were added to RDB\$TYPES. They describe the numeric values for these columns:

RDB\$PARAMETER_TYPE	(table RDB\$PROCEDURE_PARAMETERS)
RDB\$INDEX_INACTIVE	(table RDB\$INDICES)
RDB\$UNIQUE_FLAG	(table RDB\$INDICES)
RDB\$TRIGGER_INACTIVE	(table RDB\$TRIGGERS)
RDB\$GRANT_OPTION	(table RDB\$USER_PRIVILEGES)
RDB\$PAGE_TYPE	(table RDB\$PAGES)
RDB\$PRIVATE_FLAG	(tables RDB\$PROCEDURES and RDB\$FUNCTIONS)
RDB\$LEGACY_FLAG	(table RDB\$FUNCTIONS)
RDB\$DETERMINISTIC_FLAG	(table RDB\$FUNCTIONS)

Monitoring Tables

Dmitry Yemanov

Per-table performance counters have been added to all of the monitoring tables. See Tracker [CORE-4564](#).

MON\$ATTACHMENTS

New information is now available:

- Operating system user name. See Tracker [CORE-3779](#).
- Protocol and client library version. See Tracker [CORE-2780](#).
- Client host name. See Tracker [CORE-2187](#).
- authentication method used for connection (MON\$AUTH_METHOD). See Tracker [CORE-4222](#).

MON\$DATABASE

Database owner (MON\$OWNER) added. See Tracker [CORE-4218](#).

MON\$STATEMENTS

The PLAN is now included. See Tracker [CORE-2303](#).

Application Programming Interfaces

A new public API replaces the legacy one in new applications, especially object-oriented ones. The interface part can be found in the header file `Interfaces.h` in the directory `/include/firebird` beneath the installation root directory.

Note

POSIX installations have a symlink pointing to `/usr/include/firebird/Interfaces.h`

The new public API can be also used inside user-defined routines (UDR, q.v.) for callbacks inside the engine, allowing a UDR to select or modify something in the database, for example.

The main difference between the new API and the legacy one is that UDRs can query and modify data in the same connection or transaction context as the user query that called that UDR. It is now possible to write external triggers and procedures, not just external functions (UDFs).

Interfaces and the New Object-oriented API

Alex Peshkov

Firebird needed a modernised API for a number of compelling reasons.

-

High on the list was the limitation of the 16-bit integer pervading the legacy API, encompassing message size, SQL operator length, BLOB data portions, to name a few examples. While 16-bit was probably adequate when that old API came to life, in today's environments it is costly to work around.

A trivial solution might be to add new functions that support 32-bit variables. The big downside is the obvious need to retain support for the old API by having pairs of functions with the same functionality but differing integer sizes. In fact, we did something like this to support 64-bit performance counters, for no better reason than being pressed to provide for it without having a more elegant way to implement it.

- Another important reason, less obvious, derives from the era when Firebird's predecessor, InterBase, did not support SQL. It used a non-standard query language, GDML, to manage databases. Data requests were transported between client and server using messages whose formats were defined at request compilation time in BLR (binary language representation). In SQL, the operator does not contain the description of the message format so the decision was taken to surround each message with a short BLR sequence describing its format.

The ISC API also has the XSQLDA layer over BLR. The trap with the XSQLDA solution is that it encapsulates both the location of the data and their format, making it possible to change location or format (or both) between fetch calls. Hence, the need for the BLR wrapping in *every* fetch call—notwithstanding, this potential capability to change the data format between fetches was broken in the network layer before Firebird existed.

But to support the XSQLDA layer that rides on top of the message-based API that lower level API also has support sending format BLR at every turn.

This system involving calls processing data through multiple layers is hard to extend and wastes performance; the SQLDA is not simple to use; the desire to fix it was strong.

- Other reasons—numerous but perhaps less demanding—for changing the API included enhancing the status vector and optimizing dynamic library loading. Interfaces also make it so much easier and more comfortable to use the messages API.

The Non-COM Choice

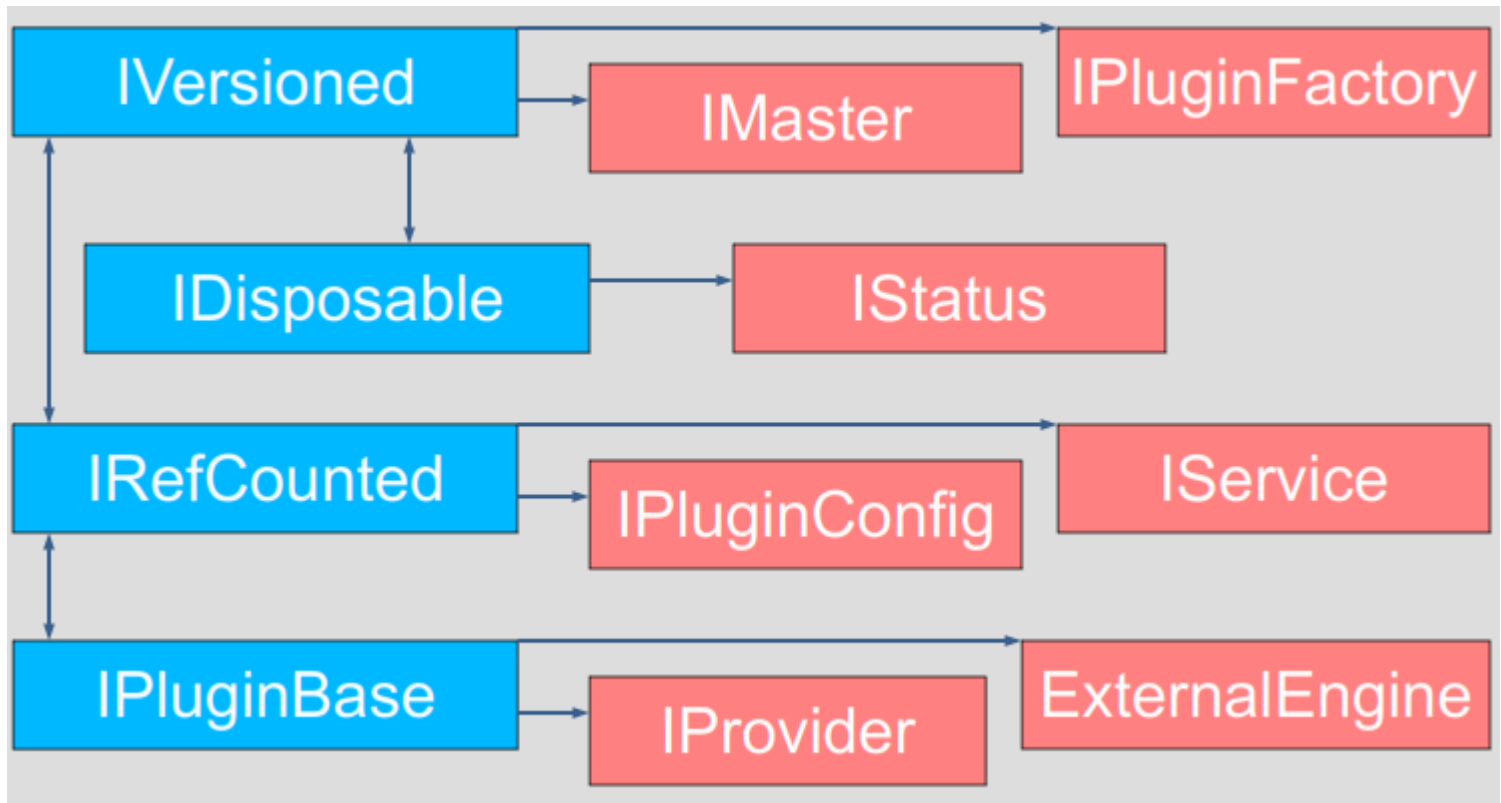
The new interfaces are not compatible with COM, deliberately, and the reasons have to do with future performance enhancement.

At the centre of the Providers architecture in Firebird 3.0 is the **y-valve**, which is directed at dispatching API calls to the correct provider. Amongst the potential providers are older ones with potentially older interfaces. If we used COM, we would have to call the method **IUnknown** for each call (including record fetch), just to ensure that the provider really had some newer API method. Along with that comes the likelihood of future additions to the catalogue of API calls to optimize performance. A COM-based solution does not play well with that.

Firebird interfaces, unlike COM, support multiple versions. The interface version is determined by the total number of virtual functions it encompasses and is stored as a pointer-size integer at the beginning of the virtual functions table. This makes it possible for very fast checking of the interface version, since it requires no virtual call. That is to say, the pointer check has no overhead, unlike COM.

The Hierarchy of Interfaces

A detailed discussion of all the functions presented by all the interfaces is outside the scope of this overview. The general schematic looks like this:



The base of the structure is **IVersioned**. It is the interface that enables a version upgrade. A lot of interfaces not requiring additional lifetime control are based directly on **IVersioned**. **IMaster** is one example already mentioned. Others include a number of callback interfaces whose lifetimes must match the lifetimes of the objects from which they were to be used for callback.

Two interfaces deal with lifetime control: **IDisposable** and **IRefCounted**. The latter is especially active in the creation of other interfaces: **IPlugin** is reference counted, as are many other interfaces that are used by plug-ins. These include the interfaces that describe database attachment, transaction management and SQL statements.

Not everything needs the extra overhead of a reference-counted interface. For example, **IMaster**, the main interface that calls functions available to the rest of the API, has unlimited lifetime by definition. For others, the API is defined strictly by the lifetime of a parent interface; the **IStatus** interface is non-threaded. For interfaces with limited lifetimes it is of benefit to have a simple way to destroy them, that is, a `dispose()` function.

Each plug-in has one and only one main interface—**IPlugin**—which is responsible for basic plug-in functionality. In fact, a lot of plug-ins have only that interface, although that is not a requirement.

Finally, there is **IProvider**, a kind of “main” plug-in in the Firebird API. **IProvider** is derived from **IPlugin** and must be implemented by every provider. If you want to write your own provider you must implement **IProvider**. It is implemented also by the **y-valve**: it is the **y-valve** implementation that is returned to the user when the `getDispatcher()` function from the master interface is called.

IProvider contains functions enabling creation of an attachment to a database (attach and create) or to the Services Manager.

Interfaces Q & A

Q. We access new API using **IMaster**. But how to get access to **IMaster** itself?

- A. This is done using just the one new API function **fb_get_master_interface()**. It is exported by the `fb-client` library. Also `IMaster` is passed as a parameter to each plug-in during its registration in the system.

Q. The non-use of COM-based interfaces was said to be to avoid working with `IUnknown` methods and that this is done due to performance issues. Instead you have to check the interface version. Why is that faster than using `IUnknown`?

- A. As was already mentioned we do not need to execute virtual calls when checking the interface version. Taking into an account that each virtual call means a reset of the CPU cache, it is an important difference, especially for the very small calls like getting specific metadata properties from `IMetadata`.

Other New APIs

Other new APIs support various plug-ins by declaring the interfaces between the engine and the plug-in. Besides pluggable authentication and pluggable encryption, Firebird 3 supports “external engines”, bridges between the engine and the execution environments that can run UDRs: native code, Java and others. By and large they are intended for use by third-party solution providers, rather than for client application development.

For creating custom plug-ins and bridges, the relevant interface (API) needs to be implemented in the plug-in code.

API Improvements

Improvements to the legacy API include.-

Better Error Reports for String Overflows

Alex Peshkov

Include expected and actual string length in the error message for string overflows (SQLCODE -802).

More Detail in “Wrong Page Type” Error Reports

Alex Peshkov

More details in the error message “wrong page type”, i.e., identifying expected and encountered page types by name instead of numerical type.

New Services Tag for Overriding LINGER

Alex Peshkov

The Services API now includes the tag **isc_spb_prp_nolinger**, for example (in one line):

```
fbsvcmgr host:service_mgr user sysdba password xxx
        action_properties dbname employee prp_nolinger
```

For information regarding `LINGER`, see [the write-up in the DDL chapter](#).

Code Improvement

Alex Peshkov

([CORE-4387](#)) The functions `IStatement::execute()` and `IAttachment::execute()` now return an error pointer to the old transaction interface.

Chapter 5

Reserved Words and Changes

New Keywords in Firebird 3.0

Reserved

BOOLEAN	RDB\$RECORD_VERSION	TRUE
DETERMINISTIC	RETURN	UNKNOWN
FALSE	SCROLL	
OVER	SQLSTATE	

Non-reserved

USAGE

Configuration Additions and Changes

The file `aliases.conf` is renamed to `databases.conf`. An old `aliases.conf` from a previous version can simply be renamed and the new engine will just continue to use it as before. However, `databases.conf` can now include some configuration information for individual databases.

Scope of Parameters

Some parameters are marked as configurable *per-database* or *per-connection*.

- Per-database configuration is done in `databases.conf`.
- Per-connection configuration is primarily for client tool use and is done using the DPB parameter **`isc_dpb_config`** or, for Services, the SPB parameter **`isc_spb_config`**.
- In the case of Embedded, the DPB can be used to tune per-database entries on first attaching to a database.

Macro Substitution

A number of predefined macros (syntax `$(name)`) is available for use in the configuration files to substitute for a directory name:

`$(root)`

Root directory of Firebird instance

`$(install)`

Directory where Firebird is installed. `$(root)` and `$(install)` are initially the same. `$(root)` can be overridden by setting or altering the environment variable `FIREBIRD`, in which case it becomes different from `$(install)`.

`$(this)`

Directory where current configuration file is located

`$(dir_conf)`

Directory where `firebird.conf` and `databases.conf` are located

`$(dir_secdb)`

Directory where the default security database is located

`$(dir_plugins)`

Directory where plugins are located

`$(dir_udf)`

Directory where UDFs are located by default

`$(dir_sample)`

Directory where samples are located

`$(dir_sampledb)`

Directory where sample DB (employee.fdb) is located

`$(dir_intl)`

Directory where international modules are located

`$(dir_msg)`

Directory where the messages file (firebird.msg) is located. `$(dir_msg)` usually should be the same as `$(root)` but can be overridden by the environment variable `FIREBIRD_MSG`.

Notes to be checked by Alex Peshkov

`$(dir_conf)` and `$(dir_secdb)` would normally be the same as `$(root)` and `$(install)`. *[To do: report whether they can be overridden and, if so, how.]*

`$(dir_plugins)`, `$(dir_udf)`, `$(dir_sample)`, `$(dir_sampledb)` and `$(dir_intl)` are just predefined sub-directories inside `$(root)`. *[To do: Could those sub-dirs be in a different location? If so, how can the macros be set?]*

Includes

One configuration file can be included in another by using an “include” directive, e.g.,

```
include some_file.conf
```

A relative path is treated as relative to the enclosing configuration file. So, if our example above is inside `/opt/config/master.conf` then our **include** refers to the file `/opt/config/some_file.conf`.

Wildcards

The standard wildcards `*` and `?` may be used in an **include** directive, to include all matching files in undefined order. For example,

```
include $(dir_plugins)/config/*.conf
```

Expression of Parameter Values

Previously, byte values were specified by default as integer, representing the number of bytes. However, now you can optionally specify them in Kilobytes, Megabytes or Gigabytes, as appropriate, by adding K, M or G (case-insensitive). For example, **24M** is read as 25165824 (24 * 1024 * 1024).

Boolean values are expressed as non-zero (true)|zero (false) by default, but you may now use the quoted strings 'y', 'yes' or 'true' instead of a non-zero digit.

“Per-database” Configuration

Custom configuration at database level is achieved with formal entries in `databases.conf`.

Format of Configuration Entries

To come.

Parameters Available

The following parameters can be copy/pasted to `databases.conf` and used as overrides for specific databases.

Table 6.1. Parameters available in `databases.conf`

Engine-related		
CryptPlugin	DatabaseGrowthIncrement	DeadlockTimeout
DefaultDbCachePages	EventMemSize	ExternalFileAccess
FileSystemCacheThreshold	GCPolicy	LockAcquireSpins
LockHashSlots	LockMemSize	MaxUnflushedWrites
MaxUnflushedWriteTime	SecurityDatabase	SharedCache
SharedDatabase	UserManager	WireCrypt
Client-related	<i>Some parameters can be configured at the client connection via the DPB/SPB, as an alternative to configuring them in <code>databases.conf</code>. Please refer back to Scope of Parameters at the beginning of this chapter to understand these differences.</i>	
AuthClient	Providers	
<i>The following parameters can be configured ONLY via the DPB/SPB</i>		
ConnectionTimeout	DummyPacketInterval	IpcName
RemoteAuxPort	RemotePipeName	RemoteServiceName
RemoteServicePort	TCPNoNagle	

New Parameters

New parameters added to `firebird.conf` are:

SecurityDatabase

Defines the name and location of the security database that stores login user names and passwords used by the server to validate remote connections. By default, in `firebird.conf`, it is `$(root)/security3.fdb`. It can be overridden for a specific database by a configuration in `databases.conf`.

AuthServer and AuthClient

Two parameters that determine what authentication methods can be used by the network server and the client redirector. The enabled methods are listed as string symbols separated by commas, semicolons or spaces.

- Secure remote passwords (Srp), using the plug-in is the default, using the OS-appropriate plug-in (`libSrp.s0` | `Srp.dll` | `Srp.dylib`)
- On Windows, the Security Support Provider Interface (Sspi) is used when no login credentials are supplied
- Client applications can use legacy authentication (`Legacy_Auth`) to talk to old servers.

For **AuthServer**, `Srp` and `Win_Sspi` are listed; for **AuthClient**, `Srp`, `Win_Sspi` and `Legacy_Auth`.

To disable a method, erase the comment marker (`#`) and remove the unwanted method from the list.

Both parameters can be used in `databases.conf`. They can both be used in the DPB or the SPB for a connection-specific configuration.

WireCrypt

Sets whether the network connection should be encrypted. It has three possible values: `Required` | `Enabled` | `Disabled`. The default is set such that encryption is `Required` for connections coming in to the server and `Enabled` for connections outgoing to a client.

To access a server using an older client library and, thus, no encryption, **WireCrypt** in the server configuration file should be set to `Enabled` or `Disabled` to avert the default *Required*.

The rules are simple: if one side has `WireCrypt = Required` and the other sets the parameter to `Disabled`, side with `WireCrypt=Required` rejects the connection and it is not established.

A missing `WireCrypt` plug-in or encryption key in cases where the channel must be encrypted also thwarts a connection.

In all other cases, connection is established without encryption if at least one side has `WireCrypt = Disabled`. In other cases, the encrypted connection is established.

UserManager

Sets the plug-in that will operate on the security database. It can be a list with blanks, commas or semicolons as separators: the first plug-in from the list is used.

The default plug-in is **Srp** (`libSrp.s0` | `Srp.dll` | `Srp.dylib`).

The `UserManager` parameter can be used in `databases.conf` for a database-specific override.

TracePlugin

Specifies the plug-in used by Firebird's Trace facility to send trace data to the client app or audit data to the log file.

The default plug-in is **fbtrace** (`libfbtrace.so` | `fbtrace.dll` | `fbtrace.dylib`).

CryptPlugin

Note

This parameter name is considered confusing and will be changed after this Beta release.

A crypt plug-in is used to encrypt and decrypt data transferred over the network.

The installation default **Arc4** implies use of an **Alleged RC4** plug-in. The configured plug-in, which requires a key generated by the configured authentication plug-in, can be overridden in the API for a specific connection via the DPB or the SPB.

Tip

For information about configuring plug-ins, see [Configuring Plug-ins](#) in the Engine chapter.

KeyHolderPlugin

This parameter would represent some form of temporary storage for database encryption keys. Nothing is implemented as a default plug-in but a sample Linux plug-in named `libCryptKeyHolder_example.so` can be found in `/plugins/`.

Providers

List of allowed transports for accessing databases, discussed in [the Engine chapter](#).

SharedCache and SharedDatabase

Two parameters that, together, determine the execution mode of the server (“server model”). Discussed in [the Engine chapter](#).

RemoteAccess

Parameter in `firebird.conf` and `databases.conf` provides an efficient, configurable replacement for hard-coded rules limiting access to `security3.fdb`. It can also be used to configure limited remote access to any other database, including non-default security databases.

By default `RemoteAccess` is enabled for all databases except the security database. If you intend using more than one dedicated security database, then disabling remote access to it (or them) via `databases.conf` is recommended.

For stricter security, server-wide, you can set `RemoteAccess` to false in `firebird.conf` and use entries in `database.conf` to re-enable it for specific databases.

`RemoteAccess` is a Boolean. It can be expressed with either true/false, 1/0 or Yes/No.

Parameters Changed or Enhanced

The following parameters have been changed or enhanced:

ExternalFileAccess

Entries in the “Restrict” list of the **ExternalFileAccess** parameter can be used to mangle file names with relative paths.

Entries in the “Restrict” list were already used to mangle file names with no path component. For example, with

```
ExternalFileAccess = /opt/extern
```

and the following sequence of commands:

```
SQL> create table qq external file 'zz' (x int);
SQL> insert into qq values(1);
SQL> commit;
```

the file `/opt/extern/zz` will be created.

But if something like this is submitted,

```
create table qq external file 'dir/zz' (x int);
```

the result is an error about denied access to file `/opt/firebird/bin/dir/zz`.

The improvement avoids this gap by mangling the file name in accord with the value of the parameter and, if necessary, creating the missing path components, such as `'dir'` in the example above.

Parameters Removed or Deprecated

The following parameters have been removed or deprecated:

RootDirectory

In older version, this parameter provided a superfluous option for recording the file system path to Firebird's "root" files (firebird.conf, the security database and so on).

LegacyHash

This parameter used to make it possible to use the old `security.fdb` from Firebird 1.X installations after it had been subjected to an upgrade script and thence to enable or disable use of the obsolete DES hash encrypting algorithm. It is no longer supported.

OldSetClauseSemantics

This parameter enabled temporary support for an implementation fault in certain sequences of SET clauses in versions of Firebird prior to v.2.5. It is no longer available.

OldColumnNaming

This parameter temporarily enabled legacy code support for an old InterBase/Firebird 1.0 bug that generated unnamed columns for computed output which was not explicitly aliased in the SELECT specification. It is no longer available.

LockGrantOrder

This parameter used to allow the option to have Firebird's Lock Manager emulate InterBase v3.3 lock allocation behaviour, whereby locks would be granted in no particular order, as soon as soon as they were available, rather than by the normal order (first-come, first-served). The legacy option is no longer supported.

Obsolete Windows priority settings

UsePriorityScheduler, PrioritySwitchDelay and PriorityBoost, which were marginally relevant to obsolete processors on obsolete Windows versions, are no longer supported.

Chapter 7

Security

Security improvements in Firebird 3 include:

Location of User Lists

Alex Peshkov

[CORE-685](#)

Firebird now supports an unlimited number of security databases. Any database may act as a security database and can be a security database for itself.

Use `databases.conf` to configure a non-default security database. This example configures `/mnt/storage/private.security.fdb` as the security database for the first and second databases:

```
first = /mnt/storage/first.fdb
{
    SecurityDatabase = /mnt/storage/private.security.fdb
}

second = /mnt/storage/second.fdb
{
    SecurityDatabase = /mnt/storage/private.security.fdb
}
```

Here we use third database as its own security database:

```
third = /mnt/storage/third.fdb
{
    SecurityDatabase = third
}
```

Note

The value of the [SecurityDatabase](#) parameter can be a database alias or the actual database path.

Database Encryption

Alex Peshkov

[CORE-657](#)

With Firebird 3 comes the ability to encrypt data stored in database. Not all of the database file is encrypted: just data, index and blob pages.

To make it possible to encrypt a database you need to obtain or write a database crypt plug-in.

Note

The sample crypt plug-in in `examples/dbcrypt` does not perform real encryption, it is merely a sample of how to go about it.

Secret Key

The main problem with database encryption is how to store the secret key. Firebird provides a helper to transfer that key from the client but that does not imply that storing the key on a client is the best way: it is no more than a possible alternative. A very bad option is to keep the key on the same disk as the database.

Tasks

To separate encryption and key access efficiently, a database crypt plug-in is split into two parts: encryption itself and the secret key holder. This may be an efficient approach for third-party plug-ins when you want to use some good encryption algorithm but you have your own secret way to store a key.

Once you have decided on a crypt plug-in and a key, you can enable them with:

```
ALTER DATABASE ENCRYPT WITH <PLUGIN_NAME>
```

Encryption will start right after this statement commits and will be performed in background. Normal database activity is not disturbed during encryption.

Tip

Encryption progress may be monitored using the field `MON$CRYPT_PAGE` in the pseudo-table `MON$DATABASE` or watching the database header page using `gstat -e`.

`gstat -h` will also provide limited information about encryption state.

To decrypt the database do:

```
ALTER DATABASE DECRYPT
```

For Linux, an example plug-in named `libDbCrypt_example.so` can be found in the `/plugins/` sub-directory.

New Authentication Method in Firebird 3

Alex Peshkov

All of the code related to authentication is plug-in-enabled. Though Firebird performs the generic work, like extracting authentication data from a network message or putting it into such messages as appropriate, all the

activity related to calculating hashes, storing data in databases or elsewhere, using specific prime numbers and so on is done by plug-ins.

Firebird 3 has new method of user authentication implemented as a default plugin: secure remote password (SRP) protocol. Quoting from [Wikipedia](#):

“The SRP protocol creates a large private key shared between the two parties in a manner similar to Diffie-Hellman key exchange, then verifies to both parties that the two keys are identical and that both sides have the user's password. In cases where encrypted communications as well as authentication are required, the SRP protocol is more secure than the alternative SSH protocol and faster than using Diffie-Hellman key exchange with signed messages. It is also independent of third parties, unlike Kerberos.”

SSH needs key pre-exchange between server and client when placing a public key on the server to make it work. SRP does not need that. All a client needs are login and password. All exchange happens when the connection is established.

Moreover, SRP is resistant to “man-in-the-middle” attacks.

Important

Use of the new authentication method is not compatible with old security databases and passwords from them. There is no way to migrate users from Firebird 2.

Use of an old security database can be supported with the [Legacy Auth](#) authentication plug-in, but this kills the security benefits of Firebird 3.

The Firebird 3 client is built to make it possible to talk to old servers with the default configuration.

SSL/TLS Support

[CORE-3251](#)

So, the answer to the question “Does Firebird use SSL/TLS for password validation?” is “yes and no”. The “No” answer comes because, by default, SSL is not used. That is due to a minor licensing incompatibility between Firebird and OpenSSL, the most popular SSL implementation.

The “Yes” applies because anyone is free to write an authentication plug-in that uses SSL and TLS.

Increased Password Length

[CORE-1898](#).

Implementation of SRP in our plugin has increased the password length from 8 bytes. Because of the use of SHA1 for hashes, it is effectively limited to 20 bytes **. A custom SRP plug-in can be built quite easily with longer passwords using another hash.

Tip

The increased length limit means the default SYSDBA's password is the full 'masterkey' string (9 chars), no longer 'masterke' (8 chars) as in older versions!

Support for the **LegacyHash** and **Authentication** parameters in `firebird.conf` has been dropped. **Authentication** is overtaken by an **AuthServer** parameter in `firebird.conf` or elsewhere.

****Why is the password effectively limited to 20 characters?**

A password of more than 20 bytes *can* be used and it will not be restricted. Hashes for passwords that differ beyond byte 20 are different. The “effective limit” is due to the limited length of the hash in SHA1—20 bytes == 160 bits. Sooner, rather than later, a shorter password with the same hash could be found using brute force. That is why it is often said that the effective password length for a SHA-1-based password is 20 bytes.

The Authentication Plug-in

The Authentication plug-in comprises three parts:

- Client—prepares data at the client to be sent to server on client
- Server—validates password for correctness
- User Manager—adds, modifies and deletes users on the server. It is not needed if some external authentication method, such as Windows trusted authentication, is used.

All three parts are actually separate plug-ins which should be configured separately in `firebird.conf`. Let's look at an example of configuring a server to accept connections from old clients. The default setting are:

```
AuthServer = Srp, Win_Sspi
UserManager = Srp
```

To enable access from old clients, `AuthServer` needs to be changed:

```
AuthServer = Srp, Win_Sspi, Legacy_Auth
```

If we also want to manage the list of users in the old format we must add:

```
UserManager = Legacy_UserManager
```

Multiple User Managers

Up to and including this Beta release, only one User Manager is possible. Later, it is planned to make it possible to enumerate more than one and add SQL support to work with all of them.

"Over the wire" Connection Encryption

Alex Peshkov

[CORE-672](#) ...

All network traffic in Firebird 3 may be optionally encrypted. As with authentication, plug-ins are used for encrypting and decrypting network traffic.

The default plug-in is **arc4** (Alleged RC4). It is eminently possible to write your own crypt plug-in to encrypt data travelling over the wire. Whatever you use for your plug-in, it is necessary to use the Firebird 3 version of the `fbclient` library.

The Secret Session Key

The challenge with use of a symmetric cypher is where to get a key for it. Firebird assumes that such a key, also called a *secret session key*, is produced by the authentication plug-in at the connection establishment phase. SRP meets this requirement just fine by producing a cryptographically strong session key.

Tip

If you want to use encryption with an authentication plug-in that does not provide the session key and agree to use some pre-defined key, say, one stored at the client side as a file and on the server in the security database for that specific client, then make that plug-in inform Firebird that it does have a session key.

Specifications for the Key

Specifications for the key's size, its format, how it is calculated and verified, etc., are not generalised. The key's format and other details are specific to the wire encryption/decryption plug-in.

In particular, RC4 uses a symmetric key which can have any length, while the key produced by SRP has a length of 20 bytes. That key is a SHA-1 hash on SRP's session key and some other SRP-related things, such as user name.

Exporting a Key from an Authentication Plug-in

To export a key from your authentication plug-in, use the *IServerBlock* or the *IClientBlock* interface. One of these is always passed to the server/client part of an authentication plug-in. Both have "void putKey(IStatus)" status, FbCryptKey* cryptKey)" method. The FbCryptKey structure is defined as follows:

```
struct FbCryptKey
{
    const char* type;                // If NULL type is auth plugin name
    const void* encryptKey;           // Sequence of bytes in encryption key
    const void* decryptKey;           // May be NULL for symmetric keys - encryptKey is used for
    unsigned encryptLength;           // Length of encryption key
    unsigned decryptLength;           // Ignored when decryptKey is NULL - encryptLength is used
};
```

Mapping of Users to Objects

Alex Peshkov

Firebird 3 introduces new SQL privileges to map access between users and groups and security objects and between databases. See Tracker item [CORE-1900](#).

With Firebird now supporting multiple security databases, some new problems arise that could not occur with a single, global security database. Clusters of databases using the same security database were efficiently sepa-

rated. Mappings provide the means to achieve the same efficiency when multiple databases are using their own security databases. Some cases require control for limited interaction between such clusters. For example:

- when EXECUTE STATEMENT ON EXTERNAL DATA SOURCE requires some data exchange between clusters
- when server-wide SYSDBA access to databases is needed from other clusters, using services.
- comparable problems that have existed on Firebird 2.1 and 2.5 for Windows, due to support for Trusted User authentication: two separate lists of users—one in the security database and another in Windows, with cases where it was necessary to relate them. An example is the demand for a ROLE granted to a Windows group to be assigned automatically to members of that group.

The single solution for all such cases is **mapping** the login information assigned to a user when it connects to a Firebird server to internal security objects in a database—CURRENT_USER and CURRENT_ROLE.

The Mapping Rule

The mapping rule consists of four pieces of information:

1. mapping scope—whether the mapping is local to the current database or whether its effect is to be global, affecting all databases in the cluster, including security databases
2. mapping name—an SQL identifier, since mappings are objects in a database, like any other
3. the object FROM which the mapping maps. It consists of four items:
 - The authentication source
plug-in name **or**
the product of a mapping in another database **or**
use of server-wide authentication **or**
any method
 - The name of the database where authentication succeeded
 - The name of the object from which mapping is performed
 - The **type** of that name—user name | role | OS group—depending upon the plug-in that added that name during authenticationAny item is accepted but only **type** is required.
4. the object TO which the mapping maps. It consists of two items:
 - The name of the object TO which mapping is performed
 - The **type**, for which only USER or ROLE is valid

Syntax for MAPPING Objects

Mappings are defined using the following set of DDL statements:

```
{CREATE | ALTER | CREATE OR ALTER} [GLOBAL] MAPPING name
  USING {
    PLUGIN name [IN database] | ANY PLUGIN [IN database | SERVERWIDE] |
    MAPPING [IN database] | '*' [IN database]}
  FROM {ANY type | type name}
  TO {USER | ROLE} [name]
  --
DROP [GLOBAL] MAPPING name
```

Description

- Any mapping may be tagged as GLOBAL.

Global mapping works best if a Firebird 3 or higher version database is used as the security database. If you plan to use another database for this purpose—using your own provider, for example—then you should create a table in it named RDB\$MAP, with the same structure as RDB\$MAP in a Firebird 3 database and with SYSDBA-only write access.

Beware!

If global and local mappings of the same name exist then know and make it known that they are different objects!

- The CREATE, ALTER and CREATE OR ALTER statements use the same set of options. The name (identifier) of a mapping is used to identify it, as in other DDL command sets.
- The USING clause has a highly complicated set of options:
 - an explicit plug-in name means it will work only for that plug-in
 - it can use any available plug-in; although not if the source is the product of a previous mapping
 - it can be made to work only with server-wide plug-ins
 - it can be made to work only with previous mapping results
 - it can be left to use any method, using the asterisk (*) argument
 - it can be provided with the name of the database that originated the mapping for the FROM object

Note

This argument is not valid for mapping server-wide authentication.

- The FROM clause takes a mandatory argument, the *type* of the object named.
 - > When mapping names from plug-ins, *type* is defined by the plug-in.
 - > When mapping the product of a previous mapping, *type* can be only USER or ROLE.
 - > If an explicit name is provided, it will be taken into account by this mapping
 - > Use the ANY keyword to work with any name of the given type.
- In the TO clause, the USER or ROLE to which the mapping is made must be specified. NAME is optional: if it is not supplied, the name from the originating mapping is used.

Examples

The examples use the CREATE syntax. Usage of ALTER is exactly the same and the usage of DROP should be obvious.

1. Enable use of Windows trusted authentication in all databases that use the current security database:

```
CREATE GLOBAL MAPPING TRUSTED_AUTH
  USING PLUGIN WIN_SSPI
  FROM ANY USER
  TO USER;
```

2. Enable SYSDBA-like access for windows admins in current database:

```
CREATE MAPPING WIN_ADMINS
  USING PLUGIN WIN_SSPI
  FROM Predefined_Group
  DOMAIN_ANY_RID_ADMINS
  TO ROLE RDB$ADMIN;
```

Note

The group DOMAIN_ANY_RID_ADMINS does not exist in Windows, but such a name would be added by the win_ssapi plug-in to provide exact backwards compatibility.

3. Enable a particular user from another database to access the current database with another name:

```
CREATE MAPPING FROM_RT
  USING PLUGIN SRP IN "rt"
  FROM USER U1 TO USER U2;
```

Important

Database names or aliases will need to be enclosed in double quotes on operating systems that have case-sensitive file names.

4. Enable the server's SYSDBA (from the main security database) to access the current database. (Assume that the database is using a non-default security database):

```
CREATE MAPPING DEF_SYSDBA
  USING PLUGIN SRP IN "security.db"
  FROM USER SYSDBA
  TO USER;
```

5. Ensure users who logged in using the legacy authentication plug-in do not have too many privileges:

```
CREATE MAPPING LEGACY_2_GUEST
  USING PLUGIN legacy_auth
  FROM ANY USER
  TO USER GUEST;
```

Legacy Mapping Rule

Previous versions of Firebird have one hard-coded global default rule: users authenticated in the security database are always mapped into any database one-to-one. It is a safe rule: it makes no sense for a security database not to trust itself!

For backward compatibility this rule is retained in Firebird 3.

Mapping Windows Users to *CURRENT_USER*

With Trusted User authentication enabled, Windows users in versions 2.1 and 2.5 are mapped automatically to *CURRENT_USER*, by default. In Firebird 3 the mapping must be done explicitly for systems with multiple security databases and Trusted User authentication enabled.

SQL Features for Managing Access

Changes in architecture, stiffening of rules for security and data integrity, along with a bucket list of feature requests, have given rise in this release to a number of new SQL commands for managing users and access to objects.

SQL-driven User Management

Alex Peshkov

The SQL set of DDL commands for managing user accounts has been enhanced in Firebird 3, thus improving the capability to manage (add, modify or delete) users in a security database from a regular database attachment.

Syntax Forms

```
CREATE USER name {PASSWORD 'password'} [ options ]
                                     [ TAGS ( tag [, tag [, tag ...]] ) ]
ALTER USER name SET [PASSWORD 'password'] [ options ]
                                     [ TAGS ( tag [, tag [, tag ...]] ) ]
ALTER CURRENT USER SET [PASSWORD 'password'] [ options ]
                                     [ TAGS ( tag [, tag [, tag ...]] ) ]
CREATE OR ALTER USER name SET [PASSWORD 'password'] [ options ]
                                     [ TAGS ( tag [, tag [, tag ...]] ) ]
DROP USER name;
```

OPTIONS is a (probably empty) list with the following options:

```
FIRSTNAME 'string value'
MIDDLENAME 'string value'
LASTNAME 'string value'
ACTIVE
INACTIVE
```

Each TAG may have one of two forms:

```
NAME = 'string value'
```

or the DROP NAME tag form to remove a user-defined attribute entirely:

```
DROP NAME
```

Note

The NAME side of the name/value pair can be any valid SQL identifier.

Older Methods Deprecated

From Firebird 3.0, multiple security databases are supported. This capability is not supported by either the *gsec* utility or the Services API. Use of both of these methods is deprecated.

Usage Details

The CREATE USER, CREATE OR ALTER USER and DROP USER clauses are available only for SYSDBA or another user granted the RDB\$ADMIN role in security database (and logged in under that role, of course.)

The PASSWORD clause is **required** when creating a new user.

An ordinary user can ALTER his own password, real name attributes and tags. Any attempt to modify another user will fail, as will an attempt to make “self” inactive or active.

If you want to modify “self”, you can use the simplified form **ALTER CURRENT USER**.

At least one of PASSWORD, FIRSTNAME, MIDDLENAME, LASTNAME, ACTIVE, INACTIVE or TAGS must be present in an ALTER USER or CREATE OR ALTER USER statement.

It is not a requirement to use any of the clauses FIRSTNAME, MIDDLENAME and LASTNAME. Any of them may be left empty or used to store short information about the user.

The INACTIVE clause is used to disable the user's login capability without dropping it. The ACTIVE clause restores that ability.

TAGS is a list of end-user defined attributes. The length of the string value should not exceed 255 bytes.

Setting a list of tags for the user retains previously set tags if they are not mentioned in the current list.

Note

A UID or GID that was entered by the deprecated *gsec* utility is treated as a tag in the SQL interface.

Examples

Generic:

```
CREATE USER superhero PASSWORD 'test';
ALTER USER superhero SET FIRSTNAME 'Clark' LASTNAME 'Kent';
CREATE OR ALTER USER superhero SET PASSWORD 'IdQfA';
DROP USER superhero;
ALTER CURRENT USER SET PASSWORD 'SomethingLongEnough';
```

Working with tags:

```
ALTER USER superhero SET TAGS (a='a', b='b');
NAME                           VALUE
=====
A                               a
B                               b

ALTER USER superhero SET TAGS (b='x', c='d');
NAME                           VALUE
=====
A                               a
B                               x
C                               d

ALTER USER superhero SET TAGS (drop a, c='sample');
NAME                           VALUE
=====
B                               x
C                               sample
```

SET ROLE

Alex Peshkov

See Tracker item [CORE-1377](#).

The SQL2008-compliant operator SET ROLE allows the CURRENT_ROLE context variable to be set to one that has been granted to the CURRENT_USER or to a user assigned to the database attachment as trusted (SET TRUSTED ROLE).

Syntax Pattern for SET ROLE

Enable CURRENT_USER access to a role that has been previously granted:

```
SET ROLE <rolename>
```

Example of SET ROLE Usage

```
SET ROLE manager;
select current_role from rdb$database;
```

Displays:

```
ROLE
```

```
=====
MANAGER
```

SET TRUSTED ROLE

The idea of a separate SET TRUSTED ROLE command is that, when the trusted user attaches to a database without providing any role info, SET TRUSTED ROLE makes a trusted role (if one exists) the CURRENT_ROLE without any additional activity, such as setting it in the DPB.

A trusted role is not a specific type of role but may be any role that was created using CREATE ROLE, or a predefined system role such as RDB\$ADMIN. It becomes a trusted role for an attachment when the [security objects mapping subsystem](#) finds a match between the authentication result passed from the plug-in and a local or global mapping for the current database. The role may be one that is not even granted explicitly to that trusted user.

Notes

- A trusted role is not assigned to the attachment by default. It is possible to change this behaviour using an appropriate authentication plug-in and a [CREATE/ALTER MAPPING](#) command.
- Whilst the CURRENT_ROLE can be changed using SET ROLE, it is not always possible to revert using the same command, because it performs an access rights check.

Syntax Pattern

Enable access to a trusted role, if the CURRENT_USER is logged in under Trusted User authentication and the role is available:

```
SET TRUSTED ROLE
```

An example of the use of a trusted role is assigning the system role RDB\$ADMIN to a Windows administrator when Windows trusted authentication is in use.

GRANT/REVOKE Rights GRANTED BY Specified User

Alex Peshkov

Previously, the grantor or revoker of SQL privileges was always the current user. This change makes it so that a different grantor or revoker can be specified in GRANT and REVOKE commands.

Syntax Pattern

```
grant <right> to <object> [ { granted by | as } [ user ] <username> ]
revoke <right> from <object> [ { granted by | as } [ user ] <username> ]
```

The **GRANTED BY** clause form is recommended by the SQL standard. The alternative form using **AS** is supported by Informix and possibly some other servers and is included for better compatibility.

Example (working as SYSDBA)

```
create role r1;
grant r1 to user1 with admin option;
grant r1 to public granted by user1;

-- (in isql)
show grant;
/* Grant permissions for this database */
GRANT R1 TO PUBLIC GRANTED BY USER1
GRANT R1 TO USER1 WITH ADMIN OPTION
```

REVOKE ALL ON ALL

When a user is removed from the security database or another authentication source, this new command is useful for revoking its access to all objects in the database.

Syntax Pattern

```
REVOKE ALL ON ALL FROM [USER] username
REVOKE ALL ON ALL FROM [ROLE] rolename
```

Example

```
# gsec -del guest
# isql employee
fbs bin # ./isql employee
Database: employee
SQL> REVOKE ALL ON ALL FROM USER guest;
SQL>
```

User Privileges for Metadata Changes

Dmitry Yemanov
with Roman Simakov

In Firebird 3, the system tables are read-only. This SQL syntax provides the means to assign metadata write privileges to specified users or roles for specified objects. See Tracker item [CORE-735](#).

Note

Some people have been applying the nickname “DDL privileges” to this feature. Don't confuse it with “DDL triggers”! A more useful nickname would be “Metadata privileges”.

Syntax Patterns

Granting metadata privileges:

```
GRANT CREATE <object-type>
TO [USER | ROLE] <user-name> | <role-name> [WITH GRANT OPTION];
```

```
GRANT ALTER ANY <object-type>
  TO [USER | ROLE] <user-name> | <role-name> [WITH GRANT OPTION];
GRANT DROP ANY <object-type>
  TO [USER | ROLE] <user-name> | <role-name> [WITH GRANT OPTION];
```

Revoking metadata privileges:

```
REVOKE [GRANT OPTION FOR] CREATE <object-type>
  FROM [USER | ROLE] <user-name> | <role-name>;
REVOKE [GRANT OPTION FOR] ALTER ANY <object-type>
  FROM [USER | ROLE] <user-name> | <role-name>;
REVOKE [GRANT OPTION FOR] DROP ANY <object-type>
  FROM [USER | ROLE] <user-name> | <role-name>;
```

Special form for database access:

```
GRANT CREATE DATABASE TO [USER | ROLE] <user-name> | <role-name>;
GRANT ALTER DATABASE
  TO [USER | ROLE] <user-name> | <role-name> [WITH GRANT OPTION];
GRANT DROP DATABASE
  TO [USER | ROLE] <user-name> | <role-name> [WITH GRANT OPTION];

REVOKE CREATE DATABASE FROM [USER | ROLE] <user-name> | <role-name>;
REVOKE [GRANT OPTION FOR] ALTER DATABASE
  FROM [USER | ROLE] <user-name> | <role-name>;
REVOKE [GRANT OPTION FOR] DROP DATABASE
  FROM [USER | ROLE] <user-name> | <role-name>;
```

Notes on Usage

- <object-type> can be any of the following:

CHARACTER SET	COLLATION	DOMAIN	EXCEPTION
FILTER	FUNCTION	GENERATOR	PACKAGE
PROCEDURE	ROLE	SEQUENCE	TABLE
VIEW			

Note

The metadata for triggers and indices are accessed through the privileges for the table that owns them.

- If the ANY option is used, the user will be able to perform any operation on any object
- If the ANY option is absent, the user will be able to perform operations on the object only if he owns it
- If the ANY option was acquired via a GRANT operation then, to revoke it, the REVOKE operation must accord with that GRANT operation

Example

```
GRANT CREATE TABLE TO Joe;
GRANT ALTER ANY TABLE TO Joe;
REVOKE CREATE TABLE FROM Joe;
```

GRANT EXECUTE Privileges for UDFs

Dmitry Yemanov

[CORE-2554](#): EXECUTE permission is now supported for UDFs (both legacy and PSQL based ones).

Syntax Pattern

```
GRANT EXECUTE ON FUNCTION <name> TO <grantee list>
[<grant option> <granted by clause>]
--
REVOKE EXECUTE ON FUNCTION <name> FROM <grantee list>
[<granted by clause>]
```

Note

The initial EXECUTE permission is granted to the function owner (user who created or declared the function).

Improvement for Recursive Stored Procedures

Alex Peshkov

A recursive stored procedure no longer requires the EXECUTE privilege to call itself. See Tracker item [CORE-3242](#).

Privileges to Protect Other Metadata Objects

New SQL-2008 compliant USAGE permission is introduced to protect metadata objects other than tables, views, procedures and functions.

Syntax Pattern

```
GRANT USAGE ON <object type> <name> TO <grantee list>
[<grant option> <granted by clause>]
--
REVOKE USAGE ON <object type> <name> FROM <grantee list>
[<granted by clause>]
--
<object type> ::= {DOMAIN | EXCEPTION | GENERATOR | SEQUENCE | CHARACTER SET | COLLATION}
```

Notes

The initial USAGE permission is granted to the object owner (user who created the object).

In Firebird 3.0 Beta 1, only USAGE permissions for exceptions ([CORE-2884](#)) and generators/sequences (gen_id, next value for: [CORE-2553](#)) are enforced. Permissions for other object types could be validated in subsequent releases, subject to further consideration of the integrity implications of allowing write access to domains, character sets and collations.

Pseudo-Tables with List of Users

[CORE-2639](#).

To access lists of users and attributes, query the virtual tables **SEC\$USERS** and **SEC\$USER_ATTRIBUTES**.

Important

This feature depends highly on the user management plug-in. Take into an account that some options are ignored when using the legacy user management plug-in.

The pseudo-tables are much like the MON\$ family tables used for monitoring the server. The table is created on demand when you run the statement

```
SELECT * FROM SEC$USERS
```

or

```
SELECT * FROM SEC$USER_ATTRIBUTES
```

The output lists the users (or their attributes) in the security database that is configured for the current database and available for management to the current user. SEC\$USERS includes a field indicating whether a user has the RDB\$ADMIN role in the security database.

Chapter 8

Data Definition Language (DDL)

Quick Links

- [BOOLEAN Data Type](#)
- [IDENTITY-Style Column](#)
- [Manage Nullability in Domains and Columns](#)
- [Modify Generators \(Sequences\)](#)
- [Alter Default Character Set](#)
-

DDL Enhancements

The following enhancements have been added to the SQL data definition language lexicon:

New Data Types

A fully-fledged Boolean type is introduced in this release, along with a surfaced emulation of the Microsoft-style “identity” column.

BOOLEAN Data Type

Adriano dos Santos Fernandes

The SQL-2008 compliant BOOLEAN data type (8 bits) comprises the distinct truth values TRUE and FALSE. Unless prohibited by a NOT NULL constraint, the BOOLEAN data type also supports the truth value UNKNOWN as the null value. The specification does not make a distinction between the NULL value of this data type and the truth value UNKNOWN that is the result of an SQL predicate, search condition, or boolean value expression: they may be used interchangeably to mean exactly the same thing.

As with many programming languages, the SQL BOOLEAN values can be tested with implicit truth values. For example, **field1 OR field2** and **NOT field1** are valid expressions.

The IS Operator

Predications use the operator IS [NOT] for matching. For example, **field1 IS FALSE**, or **field1 IS NOT TRUE**.

Note

Equivalence operators (“=”, “!=”, “<>” and so on) are valid in all comparisons.

Examples

```
CREATE TABLE TBOOL (ID INT, BVAL BOOLEAN);
COMMIT;
```

```
INSERT INTO TBOOL VALUES (1, TRUE);
INSERT INTO TBOOL VALUES (2, 2 = 4);
INSERT INTO TBOOL VALUES (3, NULL = 1);
COMMIT;
```

```
SELECT * FROM TBOOL
      ID    BVAL
=====
1 <true>
2 <false>
3 <null>
```

```
-- Test for TRUE value
SELECT * FROM TBOOL WHERE BVAL
      ID    BVAL
=====
1 <true>
```

```
-- Test for FALSE value
SELECT * FROM TBOOL WHERE BVAL IS FALSE
      ID    BVAL
=====
2 <false>
```

```
-- Test for UNKNOWN value
SELECT * FROM TBOOL WHERE BVAL IS UNKNOWN
      ID    BVAL
=====
3 <null>
```

```
-- Boolean values in SELECT list
SELECT ID, BVAL, BVAL AND ID < 2
      FROM TBOOL
      ID    BVAL
=====
1 <true>  <true>
2 <false> <false>
3 <null>  <false>
```

```
-- PSQL Declaration with start value
DECLARE VARIABLE VAR1 BOOLEAN = TRUE;
```

```
-- Valid syntax, but as with a comparison
-- with NULL, will never return any record
SELECT * FROM TBOOL WHERE BVAL = UNKNOWN
SELECT * FROM TBOOL WHERE BVAL <> UNKNOWN
```

Notes

- Represented in the API with the FB_BOOLEAN type and FB_TRUE and FB_FALSE constants.
- The value TRUE is greater than the value FALSE.
- Although BOOLEAN is not implicitly convertible to any other datatype, it can be explicitly converted to and from string with CAST.
- For compatibility reasons, the non-reserved keywords INSERTING, UPDATING and DELETING continue to behave as Boolean expressions when used in context in PSQL, while behaving as values if they are column or variable names in non-Boolean expressions.

The following example uses the word INSERTING in all three ways:

```
SELECT
  INSERTING,      -- value
  NOT INSERTING   -- keyword
FROM TEST
WHERE
  INSERTING       -- keyword
AND INSERTING IS TRUE -- value
```

Identity Column Type

Adriano dos Santos Fernandes

An identity column is a column associated with an internal sequence generator. Its value is set automatically when the column is omitted in an INSERT statement.

Syntax Patterns

```
<column definition> ::=
  <name> <type> GENERATED BY DEFAULT AS IDENTITY [ (START WITH <value>) ]<constraints>
```

When defining a column, the optional START WITH clause allows the generator to be initialised to a value other than zero. See Tracker ticket [CORE-4199](#).

```
<alter column definition> ::=
  <name> RESTART [ WITH <value> ]
```

A column definition can be altered to modify the starting value of the generator. RESTART alone resets the generator to zero; the optional WITH <value> clause allows the restarted generator to start at a value other than zero. See Tracker ticket [CORE-4206](#).

Rules

- The data type of an identity column must be an exact number type with zero scale. Allowed types are thus SMALLINT, INTEGER, BIGINT, NUMERIC(x,0) and DECIMAL(x,0).
- An identity column cannot have DEFAULT or COMPUTED value.

Notes

- An identity column cannot be altered to become a regular column. The reverse is also true.
- Identity columns are implicitly NOT NULL (non-nullable).
- Uniqueness is not enforced automatically. A UNIQUE or PRIMARY KEY constraint is required to guarantee uniqueness.
- The use of other methods of generating key values for IDENTITY columns, e.g., by trigger-generator code or by allowing users to change or add them, is discouraged to avoid unexpected key violations.

Example

```
create table objects (  
    id integer generated by default as identity primary key,  
    name varchar(15)  
);
```

```
insert into objects (name) values ('Table');  
insert into objects (name) values ('Book');  
insert into objects (id, name) values (10, 'Computer');
```

```
select * from objects;
```

```
      ID NAME  
===== =====  
      1 Table  
      2 Book  
     10 Computer
```

Implementation Details

Two new columns have been inserted in RDB\$RELATION_FIELDS to support identity columns: RDB\$GENERATOR_NAME and RDB\$IDENTITY_TYPE.

- RDB\$GENERATOR_NAME stores the automatically created generator for the column. In RDB\$GENERATORS, the value of RDB\$SYSTEM_FLAG of that generator will be 6.
- Currently, RDB\$IDENTITY_TYPE will currently always store the value 1 (by default) for identity columns and NULL for non-identity columns. In the future this column will store the value 0, too (for ALWAYS) when Firebird implements support for this type of identity column.

Manage Nullability in Domains and Columns

A. dos Santos Fernandes

ALTER syntax is now available to change the nullability of a table column or a domain

Syntax Pattern

```
ALTER TABLE <table name> ALTER <field name> [NOT] NULL
```

```
ALTER DOMAIN <domain name> [NOT] NULL
```

Notes

The success of a change in a table column from NULL to NOT NULL is subject to a full data validation on the table, so ensure that the column has no nulls before attempting the change.

A change in a domain subjects all the tables using the domain to validation.

An explicit NOT NULL on a column that depends on a domain prevails over the domain. In this situation, the changing of the domain to make it nullable does not propagate to the column.

Modify Generators (Sequences)

More statement options have been added for modifying generators (sequences). Where previously in SQL the only option was **ALTER SEQUENCE <sequence name> RESTART WITH <value>**, now a full lexicon is provided and GENERATOR and SEQUENCE are synonyms for the full range of commands.

RESTART can now be used on its own to restart the sequence at its previous start or restart value. A new column RDB\$INITIAL_VALUE is added to the system table RDB\$GENERATORS to store that value.

Syntax Forms

```
{ CREATE | RECREATE } { SEQUENCE | GENERATOR } <sequence name> [ START WITH <value> ]  
CREATE OR ALTER { SEQUENCE | GENERATOR } <sequence name> { RESTART | START WITH <value> }  
ALTER { SEQUENCE | GENERATOR } <sequence name> RESTART [ WITH <value> ]
```

Alter the Default Character Set

A. dos Santos Fernandes

```
ALTER DATABASE  
...  
SET DEFAULT CHARACTER SET <new_charset>
```

The alteration does not change any existing data. The new default character set is used only in subsequent DDL commands and will assume the default collation of the new character set.

BLOB in COMPUTED BY Expressions

Adriano dos Santos Fernandes

For Example

```
ALTER TABLE ATABLE  
ADD ABLOB  
COMPUTED BY (SUBSTRING(BLOB_FIELD FROM 1 FOR 20))
```

“Linger” Database Closure for Superserver

Sometimes it is desirable to have the Superserver engine keep the database open for a period after the last attachment is closed, i.e., to have it “linger” a while. It can help to improve performance at low cost, under conditions where the database is opened and closed frequently, by keeping resources “warm” for next time it is reopened.

Firebird 3.0 introduces an enhancement to **ALTER DATABASE** to manage this optional LINGER capability for databases running under Superserver.

Syntax Form

```
ALTER DATABASE SET LINGER TO {seconds};
ALTER DATABASE DROP LINGER;
```

Usage

To set linger for the database do:

```
ALTER DATABASE SET LINGER TO 30;  -- sets linger interval to 30 seconds
```

Either of the following forms will clear the linger setting and return the database to the normal condition (no linger):

```
ALTER DATABASE DROP LINGER;
ALTER DATABASE SET LINGER TO 0;
```

Note

Dropping LINGER is not an ideal solution for the occasional need to turn it off for some once-only condition where the server needs a forced shutdown. The *gfx* utility now has the **-NoLinger** switch, which will close the specified database immediately the last attachment is gone, regardless of the LINGER setting in the database. The LINGER setting is retained and works normally the next time.

The same one-off override is also available through the Services API, using the tag **isc_spb_prp_nolinger**, e.g. (in one line):

```
fbsvcmgr host:service_mgr user sysdba password xxx
    action_properties dbname employee prp_nolinger
```

See also Tracker ticket [CORE-4263](#) for some discussion of the development of this feature.

New SQL for Managing Users and Access Privileges

A number of new features and enhancements have been added to the DDL lexicon for managing users and their access to objects in databases. They are [described in detail](#) in Chapter 7, Security.

SQL-driven User Management

The SQL set of DDL commands for managing user accounts has been enhanced in Firebird 3, thus improving the capability to manage (add, modify or delete) users in a security database from a regular database attachment.

***gsec* is deprecated!**

The command-line and shell utility *gsec* is deprecated from this release forward. It will continue to work with `security3.fdb` but it will not work with alternative security databases.

SET ROLE and SET TRUSTED ROLE

The SQL2008-compliant operator SET ROLE allows the CURRENT_ROLE context variable to be set to one that has been granted to the CURRENT_USER or to a user assigned to the database attachment as trusted (SET TRUSTED ROLE).

GRANTED BY Clause for Privileges

Previously, the grantor or revoker of SQL privileges was always the current user. The GRANTED BY clause makes it so that a different grantor or revoker can be specified in GRANT and REVOKE commands.

REVOKE ALL ON ALL

When a user is removed from the security database or another authentication source, this new command is useful for revoking its access to all objects in the database.

GRANT/REVOKE Metadata Privileges

In Firebird 3, the system tables are read-only. This SQL syntax provides the means to assign metadata write privileges to specified users or roles for specified objects.

EXECUTE Privileges for UDFs

EXECUTE permission is now supported for UDFs (both legacy and PSQL based ones).

GRANT/REVOKE USAGE

New SQL-2008 compliant USAGE permission is introduced to protect metadata objects other than tables, views, procedures and functions.

Chapter 9

Data Manipulation Language (DML)

In this chapter are the additions and improvements that have been added to the SQL data manipulation language subset in Firebird 3.0.

Quick Links

- Supplemental SQL 2008 Features for MERGE
- Window (Analytical) Functions
- SUBSTRING With Regular Expressions
- Advanced PLAN Output
- New Internal Functions: Inverse Hyperbolic Trig Functions
- Enhancements to DATEADD() Internal Function
- TRIM() BLOB Arguments Lose 32 KB limit
- Alternatives for Embedding Quotes in String Literals
- Prohibit Edgy Mixing of Implicit/Explicit Joins
- RETURNING Clause Can be Aliased
- RETURNING Clause from Positioned Updates and Deletes
- Cursor Stability
- Improvements for Global Temporary Tables
- Improvements for DML Strings
- SIMILAR TO Performance Improvement
- OR'ed Parameter in WHERE Clause
- A Little Dialect 1 Accommodation

Supplemental SQL 2008 Features for MERGE

Adriano dos Santos Fernandes

In summary, support for MERGE was supplemented with the introduction of these features:

- Addition of the DELETE extension ([CORE-2005](#))
- Enabling the use of multiple WHEN MATCHED | NOT MATCHED clauses ([CORE-3639](#)) and ability to apply conditions to WHEN MATCHED | NOT MATCHED
- Addition of the RETURNING ... INTO ... clause ([CORE-3020](#))

The purpose of MERGE is to read data from the source and INSERT or UPDATE in the target table according to a condition. It is available in DSQL and PSQL.

Syntax Pattern

```
<merge statement> ::=
MERGE
  INTO <table or view> [ [AS] <correlation name> ]
  USING <table or view or derived table> [ [AS] <correlation name> ]
  ON <condition>
  <merge when>...
  <returning clause>

<merge when> ::=
<merge when matched> |
<merge when not matched>

<merge when matched> ::=
WHEN MATCHED [ AND <condition> ] THEN
  { UPDATE SET <assignment list> | DELETE }

<merge when not matched> ::=
WHEN NOT MATCHED [ AND <condition> ] THEN
  INSERT [ <left paren> <column list> <right paren> ]
    VALUES <left paren> <value list> <right paren>
```

Rules

At least one of <merge when matched> or <merge when not matched> should be specified.

Example

```
MERGE INTO customers c
  USING
    (SELECT * FROM customers_delta WHERE id > 10) cd
    ON (c.id = cd.id)
  WHEN MATCHED THEN
    UPDATE SET name = cd.name
  WHEN NOT MATCHED THEN
    INSERT (id, name)
    VALUES (cd.id, cd.name)
```

Notes

A right join is made between the INTO (left-side) and USING tables using the condition. UPDATE is called when a record exists in the left table (INTO), otherwise INSERT is called.

As soon as it is determined whether or not the source matches a record in the target, the set formed from the corresponding (WHEN MATCHED / WHEN NOT MATCHED) clauses is evaluated in the order specified, to check their optional conditions. The first clause whose condition evaluates to true is the one which will be executed, and the subsequent ones will be ignored.

If no record is returned in the join, INSERT is not called.

Window (Analytical) Functions

Adriano dos Santos Fernandes

According to the SQL specification, window functions (also known as analytical functions) are a kind of aggregation, but one that does not “filter” the result set of a query. The rows of aggregated data are mixed with the query result set.

The window functions are used with the OVER clause. They may appear only in the SELECT list or the ORDER BY clause of a query.

Besides the OVER clause, Firebird window functions may be *partitioned* and *ordered*.

Syntax Pattern

```
<window function> ::= <window function name>([<expr> [, <expr> ...]]) OVER (  
  [PARTITION BY <expr> [, <expr> ...]]  
  [ORDER BY <expr>  
    [<direction>]  
    [<nulls placement>]  
    [, <expr> [<direction>] [<nulls placement>] ...]  
)  
  
<direction> ::= {ASC | DESC}  
  
<nulls placement> ::= NULLS {FIRST | LAST}
```

Aggregate Functions Used as Window Functions

All aggregate functions may be used as window functions, adding the OVER clause.

Imagine a table EMPLOYEE with columns ID, NAME and SALARY, and the need to show each employee with his respective salary and the percentage of his salary over the payroll.

A normal query could achieve this, as follows:

```
select  
  id,  
  department,  
  salary,  
  salary / (select sum(salary) from employee) percentage  
from employee  
order by id;
```

Results

id	department	salary	percentage
--	-----	-----	-----
1	R & D	10.00	0.2040
2	SALES	12.00	0.2448
3	SALES	8.00	0.1632
4	R & D	9.00	0.1836
5	R & D	10.00	0.2040

The query is repetitive and lengthy to run, especially if EMPLOYEE happened to be a complex view.

The same query could be specified in a much faster and more elegant way using a window function:

```
select
  id,
  department,
  salary,
  salary / sum(salary) OVER () percentage
from employee
order by id;
```

Here, **sum(salary) over ()** is computed with the sum of all SALARY from the query (the employee table).

Partitioning

Like aggregate functions, that may operate alone or in relation to a group, window functions may also operate on a group, which is called a “partition”.

Syntax Pattern

```
<window function>(...) OVER (PARTITION BY <expr> [, <expr> ...])
```

Aggregation over a group could produce more than one row, so the result set generated by a partition is joined with the main query using the same expression list as the partition.

Continuing the employee example, instead of getting the percentage of each employee's salary over the all-employees total, we would like to get the percentage based on just the employees in the same department:

```
select
  id,
  department,
  salary,
  salary / sum(salary) OVER (PARTITION BY department) percentage
from employee
order by id;
```

Results

id	department	salary	percentage
1	R & D	10.00	0.3448
2	SALES	12.00	0.6000
3	SALES	8.00	0.4000
4	R & D	9.00	0.3103
5	R & D	10.00	0.3448

Ordering

The ORDER BY sub-clause can be used with or without partitions and, with the standard aggregate functions, make them return the partial aggregations as the records are being processed.

Example

```
select
  id,
  salary,
  sum(salary) over (order by salary) cumul_salary
from employee
order by salary;
```

The result set produced:

id	salary	cumul_salary
3	8.00	8.00
4	9.00	17.00
1	10.00	37.00
5	10.00	37.00
2	12.00	49.00

Then `cumul_salary` returns the partial/accumulated (or running) aggregation (of the `SUM` function). It may appear strange that 37.00 is repeated for the ids 1 and 5, but that is how it should work. The `ORDER BY` keys are grouped together and the aggregation is computed once (but summing the two 10.00). To avoid this, you can add the ID field to the end of the `ORDER BY` clause.

It's possible to use multiple windows with different orders, and `ORDER BY` parts like `ASC/DESC` and `NULLS FIRST/LAST`.

With a partition, `ORDER BY` works the same way, but at each partition boundary the aggregation is reset.

All aggregation functions, other than `LIST()`, are usable with `ORDER BY`.

Exclusive window functions

Beyond aggregate functions are the exclusive window functions, currently divided into *ranking* and *navigational* categories. Both sets can be used with or without partition and ordering, although the usage does not make much sense without ordering.

Ranking Functions

The rank functions compute the ordinal rank of a row within the window partition. In this category are the functions `DENSE_RANK`, `RANK` and `ROW_NUMBER`.

Syntax

```
<ranking window function> ::=
  DENSE_RANK() |
  RANK() |
  ROW_NUMBER()
```

The ranking functions can be used to create different type of incremental counters. Consider **`SUM(1) OVER (ORDER BY SALARY)`** as an example of what they can do, each of them in a different way. Following is an example query, also comparing with the `SUM` behavior.

```
select
  id,
  salary,
  dense_rank() over (order by salary),
  rank() over (order by salary),
  row_number() over (order by salary),
  sum(1) over (order by salary)
from employee
order by salary;
```

The result set:

id	salary	dense_rank	rank	row_number	sum
3	8.00	1	1	1	1
4	9.00	2	2	2	2
1	10.00	3	3	3	4
5	10.00	3	3	4	4
2	12.00	4	5	5	5

The difference between DENSE_RANK and RANK is that there is a gap related to duplicate rows (relative to the window ordering) only in RANK. DENSE_RANK continues assigning sequential numbers after the duplicate salary. On the other hand, ROW_NUMBER always assigns sequential numbers, even when there are duplicate values.

Navigational Functions

The navigational functions get the simple (non-aggregated) value of an expression from another row of the query, within the same partition.

Syntax

```
<navigational window function> ::=
  FIRST_VALUE(<expr>) |
  LAST_VALUE(<expr>) |
  NTH_VALUE(<expr>, <offset>) [FROM FIRST | FROM LAST] |
  LAG(<expr> [ [, <offset> [, <default> ] ] ] ) |
  LEAD(<expr> [ [, <offset> [, <default> ] ] ] )
```

Important to Note

FIRST_VALUE, LAST_VALUE and NTH_VALUE also operate on a window frame. Currently, Firebird always frames from the first to the current row of the partition, not to the last. This is likely to produce strange results for NTH_VALUE and especially LAST_VALUE.

Example

```
select
  id,
  salary,
```

```

first_value(salary) over (order by salary),
last_value(salary) over (order by salary),
nth_value(salary, 2) over (order by salary),
lag(salary) over (order by salary),
lead(salary) over (order by salary)
from employee
order by salary;

```

The result set:

id	salary	first_value	last_value	nth_value	lag	lead
3	8.00	8.00	8.00	<null>	<null>	9.00
4	9.00	8.00	9.00	9.00	8.00	10.00
1	10.00	8.00	10.00	9.00	9.00	10.00
5	10.00	8.00	10.00	9.00	10.00	12.00
2	12.00	8.00	12.00	9.00	10.00	<null>

FIRST_VALUE and LAST_VALUE get, respectively, the first and last value of the ordered partition.

NTH_VALUE gets the n-th value, starting from the first (default) or the last record, from the ordered partition. An offset of 1 from first would be equivalent to FIRST_VALUE; an offset of 1 from last is equivalent to LAST_VALUE.

LAG looks for a preceding row, and LEAD for a following row. LAG and LEAD get their values within a distance respective to the current row and the offset (which defaults to 1) passed.

In a case where the offset points outside the partition, the default parameter (which defaults to NULL) is returned.

Advanced Plan Output

Dmitry Yemanov

PLAN output can now be output in a more structured and comprehensible form, e.g.

```

SELECT statement
  -> First [10]
    -> Sort [SUM, O_ORDERDATE]
      -> Aggregate
        -> Sort [L_ORDERKEY, O_ORDERDATE, O_SHIPPRIORITY]
          -> Inner Loop Join
            -> Filter
              -> Table #ORDERS# Access By ID
                -> Bitmap
                  -> Index #ORDERS_ORDERDATE# Range Scan
            -> Filter
              -> Table #CUSTOMER# Access By ID
                -> Bitmap
                  -> Index #CUSTOMER_PK# Unique Scan
          -> Filter
            -> Table #LINEITEM# Access By ID
              -> Bitmap
                -> Index #LINEITEM_PK# Unique Scan

```

Advanced *PLAN* Output in *isql*

New syntax **SET EXPLAIN [ON | OFF]** has been added to the *isql* utility to surface this option. For details, refer to [SET EXPLAIN Extensions for Viewing Detailed Plans](#) in the **Utilities** chapter.

Internal Functions

Additions and enhancements to the internal functions set are:

SUBSTRING with Regular Expressions

Adriano dos Santos Fernandes

A substring search can now use a regular expression.

Search Pattern

```
SUBSTRING(<string> [NOT] SIMILAR TO <pattern> ESCAPE <char>)
```

Discussion: Tracker[CORE-2006](#)

For more information about the use of SIMILAR TO expressions, refer to `README.similar_to.txt` in the `/doc/` subdirectory of your Firebird installation.

Tip

The regex used is the SQL one. A guide is available in the DML chapter of the v.2.5 release notes and also at the [Firebird web site](#).

New Inverse Hyperbolic Trigonometric Functions

Claudio Valderrama C.

The six inverse hyperbolic trigonometric functions have been implemented internally. They are:

ACOSH

Returns the hyperbolic arc cosine of a number (expressed in radians). Format: **ACOSH(<number>)**

ASINH

Returns the hyperbolic arc sine of a number (expressed in radians). Format: **ASINH(<number>)**

ATANH

Returns the hyperbolic arc tangent of a number (expressed in radians). Format: **ATANH(<number>)**

COSH

Returns the hyperbolic cosine of an angle (expressed in radians). Format: **COSH(<number>)**

SINH

Returns the hyperbolic sine of an angle (expressed in radians). Format: **SINH(<number>)**

TANH

Returns the hyperbolic tangent of an angle (expressed in radians). Format: **TANH(<number>)**

TRIM() BLOB Arguments Lose 32 KB limit

Adriano dos Santos Fernandes

In prior versions, TRIM(substring from string) allowed BLOBs for both arguments, but the first argument had to be smaller than 32 KB. Now both arguments can take BLOBs of up to 4 GB.

Enhancements to DATEADD() Internal Function

Adriano dos Santos Fernandes

For the internal function DATEADD()

- The function now supports a fractional value for MILLISECOND. See Tracker item [CORE-4457](#).
- the data type of input <amount> arguments has changed from INTEGER to BIGINT. See Tracker item [CORE-4310](#).

DML Improvements

A collection of useful DML improvements is released with Firebird 3.

Alternatives for Embedding Quotes in String Literals

Adriano dos Santos Fernandes

It is now possible to use a character, or character pair, other than the doubled (escaped) apostrophe, to embed a quoted string inside another string. The keyword **q** or **Q** preceding a quoted string informs the parser that certain left-right pairs or pairs of identical characters within the string are the delimiters of the embedded string literal.

Syntax

```
<alternate string literal> ::=  
  { q | Q } <quote> <alternate start char> [ { <char> }... ] <alternate end char> <quote>
```

Rules

When <alternate start char> is '(', '{', '[' or '<', <alternate end char> is paired up with its respective “partner”, viz. ')', '}', ']' and '>'. In other cases, <alternate end char> is the same as <alternate start char>.

Inside the string, i.e., <char> items, single (not escaped) quotes could be used. Each quote will be part of the result string.

Examples

```
select q'{abc{def}ghi}' from rdb$database;      -- result: abc{def}ghi
select q'!That's a string!' from rdb$database;  -- result: That's a string
```

Prohibit Edgy Mixing of Implicit/Explicit Joins

Dmitry Yemanov

While mixing of implicit and explicit join syntaxes is not recommended at all, the parser still allows them. Certain “mixes” actually cause the optimizer to produce unexpected results, including “No record for fetch” errors. The same edgy styles are prohibited by other SQL engines and now they are prohibited in Firebird.

To visit some discussion on the subject, see the Tracker ticket [CORE-2812](#).

Left-side Parameters Supported

Adriano dos Santos Fernandes

The following style of subquery, with the parameter in the left side of a WHERE...IN (SELECT...) condition, would fail with the error “The data type of the parameter is unknown”.

```
SELECT <columns> FROM table_1 t1
WHERE <conditions on table_1>
AND (? IN (SELECT some_col FROM table_2 t2 WHERE t1.id = t2.ref_id))
```

Note

Better SQL coding practice would be to use EXISTS in these cases; however, developers were stumbling over this problem when using generated SQL from Hibernate, which used the undesirable style.

Enhancements to the RETURNING Clause

Adriano dos Santos Fernandes

Two enhancements were added to the RETURNING clause:

RETURNING Clause Value Can be Aliased

When using the RETURNING clause to return a value to the client, the value can now be passed under an alias.

Example Without and With Aliases

```
UPDATE T1 SET F2 = F2 * 10
RETURNING OLD.F2, NEW.F2; -- without aliases

UPDATE T1 SET F2 = F2 * 10
RETURNING OLD.F2 OLD_F2, NEW.F2 AS NEW_F2; -- with aliases
```

Note

The keyword AS is optional.

RETURNING Clause from Positioned Updates and Deletes

Support has been added for a RETURNING clause in positioned (WHERE CURRENT OF) UPDATE and DELETE statements.

Example

```
UPDATE T1 SET F2 = F2 * 10 WHERE CURRENT OF C
RETURNING NEW.F2;
```

Cursor Stability

Vlad Khorsun

Until this release, Firebird suffered from an infamous bug whereby a data modification operation could loop infinitely and, depending on the operation, delete all the rows in a table, continue updating the same rows ad infinitum or insert rows until the host machine ran out of resources. All DML statements were affected (INSERT, UPDATE, DELETE, MERGE). It occurred because the engine used an implicit cursor for the operations.

To ensure stability, rows to be inserted, updated or deleted had to be marked in some way in order to avoid multiple visits. Another workaround was to force the query to have a SORT in its plan, in order to materialize the cursor.

From Firebird 3, engine uses the Undo log to check whether a row was already inserted or modified by the current cursor.

Important

This stabilisation does NOT work with SUSPEND loops in PSQL.

An Improvement for GTTs

Vlad Khorsun

Global temporary tables (GTTs) are now writable even in read-only transactions. The effect is as follows.-

Read-only transaction in read-write database

Writable in both ON COMMIT PRESERVE ROWS and ON COMMIT DELETE ROWS

Read-only transaction in read-only database

Writable in ON COMMIT DELETE ROWS only

Also

- Rollback for GTT ON COMMIT DELETE ROWS is faster

- Rows do not need to be backed out on rollback
- Garbage collection in GTT is not delayed by active transactions of other connections

Note

The same refinements were also backported to Firebird 2.5.1.

An Improvement for DML Strings

Adriano dos Santos Fernandes

Strings in DML queries are now transformed or validated to avoid passing malformed strings to the engine internals, for example, to the MON\$STATEMENTS.MON\$SQL_TEXT column.

The solution adopted depends on the character set of the attachment.-

- NONE—non-ASCII characters are transformed to question marks
- Others—the string is checked for malformed characters

Optimizations

Optimizations made for this release included:

SIMILAR TO

Adriano dos Santos Fernandes

The performance of SIMILAR TO was improved.

OR'ed Parameter in WHERE Clause

Dmitry Yemanov

Performance for (**table.field = :param or :param = -1**) in the WHERE clause was enhanced.

Better Choices for Navigation

Dmitry Yemanov

Previously, when an ORDER plan was in a SELECT structure, the optimizer would choose the first index candidate that matched the ORDER BY or GROUP BY clause. This “first come” approach is not the best when multiple index choices are available. The Firebird 3 engine surveys all of the available choices and picks the most suitable index.

See Tracker ticket [CORE-4285](#).

Plainer Execution Path for UNION Queries

Dmitry Yemanov

Previously, the execution path for UNION queries was hierarchical, often causing redundant reads. This optimization replaces the hierarchical execution path with a plainer one that improves performance.

See Tracker ticket [CORE-4165](#).

Index Walk for Compound Index

Dmitry Yemanov

The optimizer now allows an index walk (ORDER plan) when a suitable compound index (A, B) is available for a query condition of the style **WHERE A = ? ORDER BY B**.

See Tracker ticket [CORE-1846](#).

Performance Improvement for SET STATISTICS INDEX

Vlad Khorsun

BTR_selectivity() would walk the whole leaf level of given index b-tree to calculate index selectivity. Throughout the process, the only rescheduling would happen at a disk I/O operation. The effect was to impose long waits for AST requests from concurrent attachments, such as page lock requests, monitoring, cancellation, etc. An improvement in Firebird 3 seems to solve that problem.

See Tracker ticket [CORE-1846](#).

Dialect 1 Interface

Adriano dos Santos Fernandes

Selection of SQL_INT64, SQL_DATE and SQL_TIME in dialect 1 was enabled.

See Tracker [CORE-3972](#)

Chapter 10

Procedural SQL (PSQL)

Advancements in procedural SQL (PSQL) include:

Quick Links

- [PSQL Stored Functions](#)
- [PSQL Subroutines](#)
- [Packages](#)
- [DDL Triggers](#)
- [Exceptions with Parameters](#)
- [CONTINUE in Looping Logic](#)
- [PSQL Cursor Stabilization](#)
- [PSQL Cursors as Variables](#)
- [SQLSTATE in Exception Trap](#)
- [Some Size Limits Removed Using New API](#)

PSQL Stored Functions

Dmitry Yemanov

It is now possible to write a scalar function in PSQL and call it just like an internal function.

Syntax for the DDL

```
{CREATE [OR ALTER] | ALTER | RECREATE} FUNCTION <name>
[(param1 [, ...])]
RETURNS <type>
AS
BEGIN
    ...
END
```

Tip

The CREATE statement is the *declaration syntax* for PSQL functions, parallel to DECLARE for legacy UDFs.

Example

```
CREATE FUNCTION F(X INT) RETURNS INT
AS
BEGIN
    RETURN X+1;
END;
```

```
SELECT F(5) FROM RDB$DATABASE;
```

PSQL Sub-routines

Adriano dos Santos Fernandes

The header of a PSQL module (stored procedure, stored function, trigger, executable block) can now accept sub-procedure and sub-function blocks in the header declarations for use within the body of the module.

Syntax for Declaring a Sub-procedure

```
DECLARE PROCEDURE <name> [(param1 [, ...])]
[RETURNS (param1 [, ...])]
AS
...
```

Syntax for declaring a Sub-function

```
DECLARE FUNCTION <name> [(param1 [, ...])]
RETURNS <type>
AS
...
```

Examples

```
SET TERM ^;
--
-- Sub-function in EXECUTE BLOCK
--
EXECUTE BLOCK RETURNS (N INT)
AS
  DECLARE FUNCTION F(X INT) RETURNS INT
  AS
  BEGIN
    RETURN X+1;
  END
BEGIN
  N = F(5);
  SUSPEND;
END ^
--
-- Sub-function inside a stored function
--
CREATE OR ALTER FUNCTION FUNC1 (n1 INTEGER, n2 INTEGER)
RETURNS INTEGER
AS
  DECLARE FUNCTION SUBFUNC (n1 INTEGER, n2 INTEGER)
  RETURNS INTEGER
  AS
  BEGIN
    RETURN n1 + n2;
  END
BEGIN
  RETURN SUBFUNC(n1, n2);
```

```
END ^  
--  
select func1(5, 6) from rdb$database ^
```

Packages

A. dos Santos Fernandes

Acknowledgement

This feature was sponsored with donations gathered at the fifth Brazilian Firebird Developers' Day, 2008

A package is a group of procedures and functions managed as one entity. The notion of “packaging” the code components of a database operation addresses several objectives:

Modularisation

The idea is to separate blocks of interdependent code into logical modules, as programming languages do.

In programming it is well recognised that grouping code in various ways, in namespaces, units or classes, for example, is a good thing. With standard procedures and functions in the database this is not possible. Although they can be grouped in different script files, two problems remain:

1. The grouping is not represented in the database metadata.
2. Scripted routines all participate in a flat namespace and are callable by everyone (we are not referring to security permissions here).

To facilitate dependency tracking

We want a mechanism to facilitate dependency tracking between a collection of related internal routines, as well as between this collection and other routines, both packaged and unpackaged.

Firebird packages come in two parts: a *header* (keyword `PACKAGE`) and a *body* (keyword `PACKAGE BODY`). This division is very similar to a Delphi unit, the header corresponding to the interface part and the body corresponding to the implementation part.

The header is created first (`CREATE PACKAGE`) and the body (`CREATE PACKAGE BODY`) follows.

Whenever a packaged routine determines that it uses a certain database object, a dependency on that object is registered in Firebird system tables. Thereafter, to drop, or maybe alter that object, you first need to remove what depends on it. As it is a package body that depends on it, that package body can just be dropped, even if some other database object depends on this package. When the body is dropped, the header remains, allowing you to recreate its body once the changes related to the removed object are done.

To facilitate permission management

It is good practice in general to create routines to require privileged use and to use roles or users to enable the privileged use. As Firebird runs routines with the caller privileges, it is necessary also to grant resource usage to each routine when these resources would not be directly accessible to the caller. Usage of each routine needs to be granted to users and/or roles.

Packaged routines do not have individual privileges. The privileges act on the package. Privileges granted to packages are valid for all package body routines, including private ones, but are stored for the package header.

For example:

```
GRANT SELECT ON TABLE secret TO PACKAGE pk_secret;  
GRANT EXECUTE ON PACKAGE pk_secret TO ROLE role_secret;
```

To enable “private scope”

This objective was to introduce private scope to routines; that is, to make them available only for internal usage within the defining package.

All programming languages have the notion of routine scope, which is not possible without some form of grouping. Firebird packages also work like Delphi units in this regard. If a routine is not declared in the package header (interface) and is implemented in the body (implementation), it becomes a private routine. A private routine can only be called from inside its package.

Signatures

For each routine that is assigned to a package, elements of a digital signature (the set of [routine name, parameters and return type]) are stored in the system tables.

The signature of a procedure or routine can be queried, as follows:

```
SELECT...  
-- sample query to come
```

Packaging Syntax

```
<package_header> ::=  
  { CREATE [OR ALTER] | ALTER | RECREATE } PACKAGE <name>  
  AS  
  BEGIN  
    [ <package_item> ... ]  
  END  
  
<package_item> ::=  
  <function_decl> ; |  
  <procedure_decl> ;  
  
<function_decl> ::=  
  FUNCTION <name> [( <parameters> )] RETURNS <type>  
  
<procedure_decl> ::=  
  PROCEDURE <name> [( <parameters> ) [RETURNS ( <parameters> )]]  
  
<package_body> ::=  
  { CREATE | RECREATE } PACKAGE BODY <name>  
  AS  
  BEGIN  
    [ <package_item> ... ]  
    [ <package_body_item> ... ]  
  END
```

```

<package_body_item> ::=
    <function_impl> |
    <procedure_impl>

<function_impl> ::=
    FUNCTION <name> [( <parameters> )] RETURNS <type>
    AS
    BEGIN
        ...
    END
    |
    FUNCTION <name> [( <parameters> )] RETURNS <type>
        EXTERNAL NAME '<name>' ENGINE <engine>

<procedure_impl> ::=
    PROCEDURE <name> [( <parameters> ) [RETURNS ( <parameters> )]]
    AS
    BEGIN
        ...
    END
    |
    PROCEDURE <name> [( <parameters> ) [RETURNS ( <parameters> )]]
        EXTERNAL NAME '<name>' ENGINE <engine>

<drop_package_header> ::=
    DROP PACKAGE <name>

<drop_package_body> ::=
    DROP PACKAGE BODY <name>

```

Syntax rules

- All routines declared in the header and at the start of the body should be implemented in the body with the same [signature](#), i.e., you cannot declare the routine in different ways in the header and in the body.
- Default values for procedure parameters cannot be redefined in <package_item> and <package_body_item>. They can be in <package_body_item> only for private procedures that are not declared.

Notes

- DROP PACKAGE drops the package body before dropping its header.
- The source of package bodies is retained after ALTER/RECREATE PACKAGE. The column RDB \$PACKAGES.RDB\$VALID_BODY_FLAG indicates the state of the package body. See Tracker item [CORE-4487](#).
- UDF declarations (DECLARE EXTERNAL FUNCTION) are currently not supported inside packages.
- Syntax is available for a description (COMMENT ON) for package procedures and functions and their parameters. See Tracker item [CORE-4484](#).

Simple Packaging Example

```

SET TERM ^;
-- package header, declarations only
CREATE OR ALTER PACKAGE TEST

```

```
AS
BEGIN
    PROCEDURE P1(I INT) RETURNS (O INT); -- public procedure
END

-- package body, implementation
RECREATE PACKAGE BODY TEST
AS
BEGIN
    FUNCTION F1(I INT) RETURNS INT; -- private function
    PROCEDURE P1(I INT) RETURNS (O INT)
    AS
    BEGIN
    END
    FUNCTION F1(I INT) RETURNS INT
    AS
    BEGIN
        RETURN 0;
    END
END ^
```

Note

More examples can be found in the Firebird installation, in ../examples/package/.

DDL triggers

A. dos Santos Fernandes

Acknowledgement

This feature was sponsored with donations gathered at the fifth Brazilian Firebird Developers' Day, 2008

The purpose of a “DDL trigger” is to enable restrictions to be placed on users who attempt to create, alter or drop a DDL object.

Syntax Pattern

```
<database-trigger> ::=
{CREATE | RECREATE | CREATE OR ALTER}
  TRIGGER <name>
  [ACTIVE | INACTIVE]
  {BEFORE | AFTER} <ddl event>
  [POSITION <n>]
AS
BEGIN
  ...
END

<ddl event> ::=
ANY DDL STATEMENT
| <ddl event item> [{OR <ddl event item>}...]

<ddl event item> ::=
  CREATE TABLE
```

```
ALTER TABLE
DROP TABLE
CREATE PROCEDURE
ALTER PROCEDURE
DROP PROCEDURE
CREATE FUNCTION
ALTER FUNCTION
DROP FUNCTION
CREATE TRIGGER
ALTER TRIGGER
DROP TRIGGER
CREATE EXCEPTION
ALTER EXCEPTION
DROP EXCEPTION
CREATE VIEW
ALTER VIEW
DROP VIEW
CREATE DOMAIN
ALTER DOMAIN
DROP DOMAIN
CREATE ROLE
ALTER ROLE
DROP ROLE
CREATE SEQUENCE
ALTER SEQUENCE
DROP SEQUENCE
CREATE USER
ALTER USER
DROP USER
CREATE INDEX
ALTER INDEX
DROP INDEX
CREATE COLLATION
DROP COLLATION
ALTER CHARACTER SET
CREATE PACKAGE
ALTER PACKAGE
DROP PACKAGE
CREATE PACKAGE BODY
DROP PACKAGE BODY
```

Semantics

1. BEFORE triggers are fired before changes to the system tables. AFTER triggers are fired after system table changes.

Important Rule

The event type [BEFORE | AFTER] of a DDL trigger cannot be changed.

2. When a DDL statement fires a trigger that raises an exception (BEFORE or AFTER, intentionally or unintentionally) the statement will not be committed. That is, exceptions can be used to ensure that a DDL operation will fail if the conditions are not precisely as intended.
3. DDL trigger actions are executed only when *committing* the transaction in which the affected DDL command runs. Never overlook the fact that what is possible to do in an AFTER trigger is exactly what is possible to do after a DDL command without autocommit. You cannot, for example, create a table in the trigger and use it there.

4. With “CREATE OR ALTER” statements, a trigger is fired one time at the CREATE event or the ALTER event, according to the previous existence of the object. With RECREATE statements, a trigger is fired for the DROP event if the object exists, and for the CREATE event.
5. ALTER and DROP events are generally not fired when the object name does not exist. For the exception, see point 6.
6. The exception to rule 5 is that BEFORE ALTER/DROP USER triggers fire even when the user name does not exist. This is because, underneath, these commands perform DML on the security database and the verification is not done before the command on it is run. This is likely to be different with embedded users, so do not write code that depends on this.
7. If some exception is raised after the DDL command starts its execution and before AFTER triggers are fired, AFTER triggers will not be fired.
8. Packaged procedures and triggers do not fire individual {CREATE | ALTER | DROP} {PROCEDURE | FUNCTION} triggers.

Permissions

The following users can create, alter or drop DDL triggers and access the [trigger-related switches](#) in the Firebird utilities:

- the database owner
- SYSDBA
- a user logged in under the RDB\$ADMIN role
- a user having the ALTER DATABASE [metadata privilege](#)

Support in Utilities

A DDL trigger is a type of database trigger, so the parameters **-nodbtriggers** (GBAK and ISQL) and **-T** (NBACKUP) apply to them. Remember that only users with the appropriate metadata privileges can use these switches.

DDL_TRIGGER Context Namespace

The introduction of DDL triggers brings with it the new **DDL_TRIGGER** namespace for use with RDB \$GET_CONTEXT. Its usage is valid only when a DDL trigger is running. Its use is valid in stored procedures and functions called by DDL triggers.

The DDL_TRIGGER context works like a stack. Before a DDL trigger is fired, the values relative to the executed command are pushed onto this stack. After the trigger finishes, the values are popped. So in the case of cascade DDL statements, when an user DDL command fires a DDL trigger and this trigger executes another DDL command with EXECUTE STATEMENT, the values of the DDL_TRIGGER namespace are the ones relative to the command that fired the last DDL trigger on the call stack.

Elements of DDL_TRIGGER Context

- EVENT_TYPE: event type (CREATE, ALTER, DROP)
- OBJECT_TYPE: object type (TABLE, VIEW, etc)
- DDL_EVENT: event name (<ddl event item>), where <ddl_event_item> is EVENT_TYPE || ' ' || OBJECT_TYPE
- OBJECT_NAME: metadata object name
- SQL_TEXT: sql statement text

Examples Using DDL Triggers

Here is how you might use a DDL trigger to enforce a consistent naming scheme, in this case, stored procedure names should begin with the prefix “SP_”:

```
set auto on;
create exception e_invalid_sp_name 'Invalid SP name (should start with SP_)';

set term !;

create trigger trig_ddl_sp before CREATE PROCEDURE
as
begin
    if (rdb$get_context('DDL_TRIGGER', 'OBJECT_NAME') not starting 'SP_') then
        exception e_invalid_sp_name;
end!

-- Test

create procedure sp_test
as
begin
end!

create procedure test
as
begin
end!

-- The last command raises this exception and procedure TEST is not created
-- Statement failed, SQLSTATE = 42000
-- exception 1
-- -E_INVALID_SP_NAME
-- -Invalid SP name (should start with SP_)
-- -At trigger 'TRIG_DDL_SP' line: 4, col: 5

set term ;!
```

Implement custom DDL security, in this case restricting the running of DDL commands to certain users:

```
create exception e_access_denied 'Access denied';
```

```
set term !;

create trigger trig_ddl before any ddl statement
as
begin
    if (current_user <> 'SUPER_USER') then
        exception e_access_denied;
end!

-- Test

create procedure sp_test
as
begin
end!

-- The last command raises this exception and procedure SP_TEST is not created
-- Statement failed, SQLSTATE = 42000
-- exception 1
-- -E_ACCESS_DENIED
-- -Access denied
-- -At trigger 'TRIG_DDL' line: 4, col: 5

set term ;!
```

Use a trigger to log DDL actions and attempts:

```
create sequence ddl_seq;

create table ddl_log (
    id bigint not null primary key,
    moment timestamp not null,
    user_name varchar(31) not null,
    event_type varchar(25) not null,
    object_type varchar(25) not null,
    ddl_event varchar(25) not null,
    object_name varchar(31) not null,
    sql_text blob sub_type text not null,
    ok char(1) not null
);

set term !;

create trigger trig_ddl_log_before before any ddl statement
as
    declare id type of column ddl_log.id;
begin
    -- We do the changes in an AUTONOMOUS TRANSACTION, so if an exception happens
    -- and the command didn't run, the log will survive.
    in autonomous transaction do
        begin
            insert into ddl_log (id, moment, user_name, event_type, object_type,
                                ddl_event, object_name, sql_text, ok)
            values (next value for ddl_seq, current_timestamp, current_user,
                    rdb$get_context('DDL_TRIGGER', 'EVENT_TYPE'),
                    rdb$get_context('DDL_TRIGGER', 'OBJECT_TYPE'),
                    rdb$get_context('DDL_TRIGGER', 'DDL_EVENT'),
                    rdb$get_context('DDL_TRIGGER', 'OBJECT_NAME'),
                    rdb$get_context('DDL_TRIGGER', 'SQL_TEXT'),
```

```

        'N')
        returning id into id;
        rdb$set_context('USER_SESSION', 'trig_ddl_log_id', id);
    end
end!

-- Note: the above trigger will fire for this DDL command. It's good idea to
-- use -nodbtriggers when working with them!
create trigger trig_ddl_log_after after any ddl statement
as
begin
    -- Here we need an AUTONOMOUS TRANSACTION because the original transaction
    -- will not see the record inserted on the BEFORE trigger autonomous
    -- transaction if user transaction is not READ COMMITTED.
    in autonomous transaction do
        update ddl_log set ok = 'Y'
        where id = rdb$get_context('USER_SESSION', 'trig_ddl_log_id');
    end!

commit!

set term ;!

-- Delete the record about trig_ddl_log_after creation.
delete from ddl_log;
commit;

-- Test

-- This will be logged one time
-- (as T1 did not exist, RECREATE acts as CREATE) with OK = Y.
recreate table t1 (
    n1 integer,
    n2 integer
);

-- This will fail as T1 already exists, so OK will be N.
create table t1 (
    n1 integer,
    n2 integer
);

-- T2 does not exist. There will be no log.
drop table t2;

-- This will be logged twice
-- (as T1 exists, RECREATE acts as DROP and CREATE) with OK = Y.
recreate table t1 (
    n integer
);

commit;

select id, ddl_event, object_name, sql_text, ok
    from ddl_log order by id;

```

ID	DDL_EVENT	OBJECT_NAME	SQL_TEXT	OK
2	CREATE TABLE	T1	80:3	Y


```
SQL_TEXT:
recreate table t1 (
    n1 integer,
    n2 integer
)
=====
3 CREATE TABLE T1 80:2 N
=====
SQL_TEXT:
create table t1 (
    n1 integer,
    n2 integer
)
=====
4 DROP TABLE T1 80:6 Y
=====
SQL_TEXT:
recreate table t1 (
    n integer
)
=====
5 CREATE TABLE T1 80:9 Y
=====
SQL_TEXT:
recreate table t1 (
    n integer
)
=====
```

Exceptions with parameters

Adriano dos Santos Fernandes

An exception can now be defined with a message containing slots for parameters which are filled and passed when raising the exception, using the syntax pattern

```
EXCEPTION <name> USING ( <value list> )
```

Examples

```
create exception e_invalid_val 'Invalid value @1 for the field @2';
```

```
...
if (val < 1000) then
    thing = val;
else
    exception e_invalid_val using (val, 'thing');
end
```

```
CREATE EXCEPTION EX_BAD_SP_NAME
'Name of procedures must start with '@1' : '@2'';
```

```
CREATE TRIGGER TRG_SP_CREATE BEFORE CREATE PROCEDURE
AS
DECLARE SP_NAME VARCHAR(255);
BEGIN
    SP_NAME = RDB$GET_CONTEXT('DDL_TRIGGER', 'OBJECT_NAME');

    IF (SP_NAME NOT STARTING 'SP_')
    THEN EXCEPTION EX_BAD_SP_NAME USING ('SP_', SP_NAME);
END;
```

Notes

The status vector is generated using this code combination: `isc_except, <exception number>, isc_formatted_exception, <formatted exception message>, <exception parameters>`

Since a new error code (`isc_formatted_exception`) is used, the client must be v.3.0, or at least use the `fire-bird.msg` file from v.3.0, in order to translate the status vector to a string.

Considering, in left-to-right order, each parameter passed in the exception-raising statement as “the Nth”, with N starting at 1:

- If an Nth parameter is not passed, the text is not substituted.
- If NULL is passed, it is replaced by the string `*** null ***`.
- If more parameters are passed than are defined in the exception message, the surplus ones are ignored.
- The total length of the message, including the values of the parameters, is still limited to 1053 bytes.

CONTINUE in Looping Logic

Adriano dos Santos Fernandes

CONTINUE is a complementary command to BREAK/LEAVE, allowing flow of control to break (leave) and start of the next iteration of a FOR/WHILE loop.

Syntax

```
CONTINUE [<label>];
```

Example

```
FOR SELECT A, D FROM ATABLE INTO :achar, :ddate
DO BEGIN
    IF (ddate < current_data - 30) THEN
        CONTINUE;
    ELSE
        /* do stuff */
    ...
END
```

PSQL Cursor Stabilization

Vlad Khorsun

PSQL cursors without SUSPEND inside are now stable:

```
FOR SELECT ID FROM T WHERE VAL IS NULL INTO :ID
DO BEGIN
    UPDATE T SET VAL = 1
    WHERE ID = :ID;
END
```

Previously, this block would loop interminably. Now, the loop will not select the value if it was set within the loop.

Note

This could change the behaviour of legacy code.

If there is a SUSPEND inside the block, the old instability remains: this query, for example, still produces the infinite loop:

```
FOR SELECT ID FROM T INTO :ID
DO BEGIN
    INSERT INTO T (ID) VALUES (:ID);
    SUSPEND;
END
```

Extension of Colon Prefix Usage

Adriano dos Santos Fernandes

Hitherto, the colon (:) prefix has been used in PSQL to mark a reference to a variable in DML statements. Its use has been extended in Firebird 3 for two unrelated purposes:

1. to allow OLD/NEW fields in cursors to be read or assigned to and to assign them to variables.
2. to make variable assignment in both DML and PSQL statements in modules and blocks more flexible and, where needed, to resolve ambiguity between field names and variable names

PSQL Cursors as Variables

Referencing cursors as record variables is now supported in PSQL. Either explicit (DECLARE AS CURSOR) or implicit (FOR SELECT) PSQL cursors make their current record available via the cursor name, thus making the INTO clause optional.

In FOR SELECT loops, it requires the AS CURSOR clause to be specified. For example:

```
execute block as
begin
  for
    select id, x from t1 as cursor c1
  do begin
    for select id, x from t2 where x = :c1.x as cursor c2 do
      begin
        /* . . . */
      end
    end
  end
end
```

Note

Notice the extension of the use of a colon (:) as a prefix to the referenced cursor field.

Another example

```
for
  select rdb$relation_id as id, rdb$relation_name as name
  from rdb$relations
  where rdb$view_blr is null
  as cursor tables
do begin
  out_id = tables.id;
  out_name = tables.name;
  suspend;
end
```

To avoid ambiguity, the colon prefix could be used:

```
out_id = :tables.id;
out_name = :tables.name;
/* or */
:out_id = :tables.id;
:out_name = :tables.name;
```

“tables” here is a cursor name and acts similarly to OLD/NEW in triggers.

Colon Prefix as a Variable Marker

It is now valid to apply the colon prefix to a variable on either side of an assignment statement in PSQL-only constructs.

Previously, these were valid assignments:

```
var1 = :var2;
/* or */
new.fld = :var;
```

whereas, these were invalid:

```
:var1 = :var2;
/* or */
:new.fld = :var;
```

The extension ([CORE-4434](#)) fixes this inconsistency.

This is now valid syntax:

```
create trigger t1 before insert on t1
as
  declare v integer;
begin
  :v = :old.n;
  :new.n = :v;
end
```

In fact, using this example, there is no difference between

```
:v = :old.n;
/* and */
v = :old.n;
```

Here, it is just “syntactic sugar” but, in other cases, it provides the means to resolve ambiguity between field name references and variable names.

Example of possible ambiguity

```
for
  select rdb$relation_id as id, rdb$relation_name as name
  from rdb$relations
  where rdb$view_blr is null
  as cursor tables
do begin
  out_id = :table.id;
  select tables.name from tables where tables.id = :tables.id into :out_name;
  suspend;
end
```

Inside the nested SELECT, “tables” is both a table name and a cursor name here, so the colon is used to resolve the ambiguity.

Some Size Limits Removed Using New API

Dmitry Yemanov

If and only if the new API is being used:

- The size of the body of a stored procedure or a trigger can exceed the traditional limit of 32 KB. The theoretical limit provided by the new API is 4GB. At the moment, as a security measure, the hardcoded limit is 10MB. It may change before the final release.

- The total size of all input or output parameters for a stored procedure or a user-defined DSQL query is no longer limited to the traditional size of (64KB minus overhead). Of course, there is a limit: it continues to be (maximum SQL text size minus overhead).

SQLSTATE in Exception Handlers

Dmitry Yemanov

In the Beta2 release of Firebird 3 an SQLSTATE code will become a valid condition for trapping an exception with a `WHEN` statement.

Chapter 11

Monitoring & Command-line Utilities

No new monitoring features or other utilities are released with Firebird 3.0. Existing features have undergone a few improvements.

Monitoring

Dmitry Yemanov

Several changes have been made to the set of virtual tables storing the monitoring information. These are listed in the [System Tables](#) section of Chapter 4, *Changes to the Firebird API and ODS*.

Tracing

Vlad Khorsun

Latest improvements to the Trace functions include:

- Trace output now supports showing the explained plan. See Tracker [CORE-4451](#).
- Tracing execution of stored functions. See Tracker [CORE-4345](#)

gbak

Alex Peshkov

New “Skip Data” Backup Option

gbak has a new option switch-- `-skip_d(ata)` to ignore the data from specific tables during a backup.

The switch `-skip_d(ata)` accepts a regular expression as its argument. For example, to skip two tables in the employee database (aliased here as 'employee'):

```
gbak -skip_d '(sales|customer)' employee e1.fbk
```

Tip

The regex used is the SQL one—the same one that is used for Firebird's SIMILAR TO searches. A guide is available in the DML chapter of the v.2.5 release notes and also at the [Firebird web site](#).

Long Names for Log Files

This improvement allows the *gbak* log to take an extra-long name without encountering the message “Attempt to store 256 bytes in a clumplet”.

gsec

The *gsec* utility is deprecated from Firebird 3 forward. This means you are encouraged to use the new [SQL features for managing access](#) described in Chapter 7, **Security**, in preference to existing equivalents provided by *gsec*.

Important

gsec will continue to work with `security3.fdb`. However, it does not work with alternative security databases.

isql

SET EXPLAIN Extensions for Viewing Detailed Plans

Dmitry Yemanov

A new SET option is added: SET EXPLAIN [ON | OFF]. It extends the SET PLAN option to report the [explained plan](#) instead of the standard one.

If SET PLAN is omitted, then SET EXPLAIN turns the plan output on. SET PLANONLY works as in previous versions.

Usage options

SET PLAN = simple plan + query execution

SET PLANONLY = simple plan, no query execution

SET PLAN + SET EXPLAIN = explained plan + query execution

SET PLAN + SET EXPLAIN + SET PLANONLY = explained plan, no query execution

SET EXPLAIN = explained plan + query execution

SET EXPLAIN + SET PLANONLY = explained plan, no query execution

Metadata Extract

Claudio Valderrama C.

The metadata extract tool (`-[e]x[tract]` switch) was improved to create a script that takes the dependency order of objects properly into account.

Path to INPUT Files

Adriano dos Santos Fernandes

The INPUT command will now use a relative path based on the directory of the last-opened, unclosed file in the chain to locate the next file.

Command Buffer Size Increase

Adriano dos Santos Fernandes

The size of the *isql* command buffer has increased from 64 KB to 10 MB to match the new engine limits. See Tracker ticket [CORE-4148](#).

fb_lock_print

Input Arguments

Dmitry Yemanov

fb_lock_print now accepts 32-bit integers as the input arguments for seconds and intervals. Previously they were limited to SMALLINT.

Useability Improvements

Vlad Khorsun

A few other small improvements:

1. More detailed usage help is available from the command line (-help).
2. Events history and list of owners are no longer output by default: they may be requested explicitly if required. Header-only is the new default.
3. New -o[wners] switch to print only owners (locks) with pending requests

gfix

-NoLinger Switch

Alex Peshkov

gfix has a new switch **-NoLinger** to provide a one-off override to the LINGER setting of a database.

For information regarding LINGER, see [the write-up in the DDL chapter](#).

Improvements to Validation Messages

Vlad Khorsun

- Critical validation messages are now split from minor ones
- The table name is now returned in the text of validation constraint error messages, to help identify the error context

Other Tweaks

Some implementation annoyances were cleared up in several utilities.

All Command-line Utilities

Resolution of Database Path

Alex Peshkov

All utilities resolve database paths in `databases.conf` when they need to access a database file directly. But not all of them would follow the same rules when expanding a database name. Now, they do.

Help and Version Information

Claudio Valderrama C.

All command-line utilities except *gpre* and *qli* now present help and version information in a unified and coherent way.

No info yet at [CORE-2540](#).

Hard-coded Messages Replaced

Claudio Valderrama C.

Hard-coded messages were replaced with the regular parameterised-style ones in *tracemanager* and *nbackup*.

Arbitrary Switch Syntax Clean-up

Claudio Valderrama C.

Switch options in *qli* and *nbackup* were made to check the correctness (or not) of the abbreviated switch options presented.

Chapter 12

Bugs Fixed

Firebird 3.0 First Beta Release

The following improvements and bug fixes were reported as fixed prior to the v.3.0.0 release:

Core Engine

([CORE-4576](#)) The Cache Writer thread could not start.

fixed by V. Khorsun

~ ~ ~

([CORE-4574](#)) Regression: Incorrect result in subquery with aggregate.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4570](#)) ALTER PACKAGE was returning a wrong error.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4566](#)) Incorrect size of the output parameter or argument when EXECUTE BLOCK, procedure or function used a system field in the metadata character set.

fixed by A. Peshkov

~ ~ ~

([CORE-4565](#)) GDSCODE could have value = 0 in WHEN-section under some concurrent environments. This bug affected Superclassic and Classic models but not Superserver.

fixed by V. Khorsun

~ ~ ~

([CORE-4555](#)) A DDL trigger was remaining active after being dropped.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4530](#)) A DB_KEY based join of two tables could be ineffective.

fixed by D. Yemanov

~ ~ ~

([CORE-4522](#)) DDL permissions were not protecting against removal of BLOB filters.

fixed by R. Simakov

~ ~ ~

([CORE-4515](#)) Regression: trace was reporting UPDATES in statistics when doing INSERT into <some_table>.

fixed by D. Yemanov

~ ~ ~

([CORE-4505](#)) Use of a named cursor would fail if a statement was not executed.

fixed by A. Peshkov

~ ~ ~

([CORE-4488](#)) A **FOR SELECT <L> FROM <T> AS CURSOR <C>** seems to return a wrong result if table <T> is modified inside the cursor's BEGIN...END block. Cursor references, which are not variables, should represent the current state of the record. If it was updated "in place" (via "where current of"), then cursor references should return the new values. The first example reported in [CORE-4488](#) should return NULLs.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4478](#)) Failure to load a provider or plugin was not reported anywhere.

fixed by A. Peshkov

~ ~ ~

([CORE-4477](#)) The field RDB\$MAP_TO_TYPE was missing from the system table RDB\$TYPES.

fixed by A. Peshkov

~ ~ ~

([CORE-4468](#)) CREATE USER GRANT ADMIN ROLE did not work.

fixed by A. Peshkov

~ ~ ~

([CORE-4464](#)) Duplicate tags for CREATE/ALTER USER were not handled correctly.

fixed by A. Peshkov

~ ~ ~

([CORE-4453](#)) Regression: The NOT NULL constraint, if declared in a domain, did not work.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4447](#)) A positioned UPDATE statement would preclude its index usage for the subsequent cursor field references.

fixed by D. Yemanov

~ ~ ~

([CORE-4444](#)) Engine could hang and block all attachments in an out-of-disk-space condition during physical backup.

fixed by V. Khorsun

~ ~ ~

([CORE-4433](#)) GlobalRWLock could not downgrade an EX lock to SH if readers were present.

fixed by V. Khorsun

~ ~ ~

([CORE-4435](#)) After calling `release()` instead of `detach()` for an attachment to a database in embedded mode, the attachment would remain interminably active.

fixed by A. Peshkov

~ ~ ~

([CORE-4430](#)) Properties of a user created in `Legacy_ UserManager` were padded with spaces up to 10 characters.

fixed by A. Peshkov

~ ~ ~

([CORE-4415](#)) Pointless extraction of generic DDL trigger.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4396](#)) A query executed via `EXECUTE STATEMENT` was returning the wrong result.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4395](#)) `EXECUTE STATEMENT ON EXTERNAL` was not finding a Firebird 2.5 database.

fixed by A. Peshkov

~ ~ ~

([CORE-4394](#)) "Cursor not found error" when using the legacy API.

fixed by A. Peshkov

~ ~ ~

([CORE-4388](#)) SELECT WITH LOCK could enter an infinite loop for a single record.

fixed by D. Yemanov

~ ~ ~

([CORE-4381](#)) Run-time errors were returning incorrect line/column information.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4379](#)) Explicit cursors containing correlated subqueries in the select list were performing poorly.

fixed by D. Yemanov

~ ~ ~

([CORE-4376](#)) Preparation of an erroneous DDL statement was not indicating that the main command failed.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4375](#)) A procedure would execute infinitely if it contained more than 32767 statements inside any BEGIN/END block.

fixed by D. Yemanov

~ ~ ~

([CORE-4374](#)) Truncation error when using EXECUTE STATEMENT with a BLOB.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4373](#)) Package compilation was not checking for duplicate names.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4372](#)) Deadlock could occur when two data pages contained record fragments pointing to each other.

fixed by V. Khorsun

~ ~ ~

([CORE-4371](#)) A CREATE FUNCTION or CREATE PROCEDURE statement that referred to a non-existent exception would return the error message "Error while parsing function's BLR" instead of "exception not defined".

fixed by D. Yemanov

~ ~ ~

([CORE-4366](#)) A WHERE predicate containing NULL IS NOT DISTINCT FROM (select min(NULL) from ...) was returning the wrong result.

fixed by D. Yemanov

~ ~ ~

([CORE-4365](#)) Equality predicate distribution was not working for some complex queries.

fixed by D. Yemanov

~ ~ ~

([CORE-4360](#)) SELECT from derived table which contains GROUP BY on a column with a literal value was returning wrong results.

fixed by D. Yemanov

~ ~ ~

([CORE-4354](#)) Parsing of a recursive query would return the error “Column does not belong to referenced table” when the source table did have such a column.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4353](#)) Sorting records were larger than was really necessary.

fixed by D. Yemanov

~ ~ ~

([CORE-4344](#)) Error “no current record for fetch operation” when table inner joins procedure inner joins table.

fixed by D. Yemanov

~ ~ ~

([CORE-4334](#)) Resources (e.g. sort files) owned by a trigger could be left unreleased when the trigger was interrupted asynchronously.

fixed by D. Yemanov

~ ~ ~

([CORE-4331](#)) LAG, LEAD and NTH_VALUE would raise an error when the second argument was NULL.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4330](#)) The function LAG returned an incorrect result if the OFFSET value was assigned from a table.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4326](#)) The keyword SET was required in the ALTER USER statement when it should have been optional.

fixed by A. Peshkov

~ ~ ~

([CORE-4318](#)) Regression: Predicates involving PSQL variables or parameters were not pushed inside the aggregation.

fixed by D. Yemanov

~ ~ ~

([CORE-4313](#)) Error “Attempt to reopen an open cursor” could be raised if the query handle was reused in a different transaction.

fixed by D. Yemanov

~ ~ ~

([CORE-4309](#)) The 'Cache Writer' record in MON\$ATTACHMENTS would vanish when deleting, via delete from MON\$ATTACHMENTS, another connection that was running a heavy update on a big table.

fixed by V. Khorsun

~ ~ ~

([CORE-4307](#)) Any fields present only in the WHERE clause of a view WITH CHECK OPTION would cause an invalid CHECK CONSTRAINT violation.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4303](#)) Possible races during service destruction.

fixed by A. Peshkov

~ ~ ~

([CORE-4301](#)) Non-ASCII data in SEC\$USERS was not read correctly.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4286](#)) The error “Statement already has a cursor assigned” would be thrown when trying to execute another SQL statement using a different cursor name.

fixed by A. Peshkov

~ ~ ~

([CORE-4118](#)) Expression index might be overlooked for derived fields or view fields.

fixed by D. Yemanov

~ ~ ~

([CORE-3305](#)) A “BLOB not found” error would be returned after creating or altering an invalid trigger.

fixed by D. Yemanov

~ ~ ~

([CORE-2350](#)) An over-long column name for a SELECT alias was not being rejected, as it should have been.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-1475](#)) A database which had active attachments could not be replaced from a backup file even after the database was shut down.

fixed by D. Yemanov

~ ~ ~

Server Crashes

([CORE-4575](#)) The server would crash in the garbage collector thread at disconnect of the last attachment.

fixed by V. Khorsun

~ ~ ~

([CORE-4568](#)) The server could crash while disconnecting from the database under load.

fixed by D. Yemanov

~ ~ ~

([CORE-4510](#)) A database validation bug could cause the server to crash.

fixed by V. Khorsun

~ ~ ~

([CORE-4506](#)) The server would crash when executing almost any "show ..." commands after a reconnect.

fixed by A. Peshkov

~ ~ ~

([CORE-4500](#)) Firebird would crash after an unsuccessful remapping of the lock table's shared memory.

fixed by D. Yemanov

~ ~ ~

([CORE-4498](#)) The server would crash when getting an explained plan for a DBKEY-based retrieval.

fixed by D. Yemanov

~ ~ ~

([CORE-4422](#)) The server would crash when using ROW_NUMBER()over(PARTITION BY x) in an ORDER by clause.

fixed by D. Yemanov

~ ~ ~

([CORE-4419](#)) The server could crash while sorting records longer than 128KB.

fixed by D. Yemanov

~ ~ ~

([CORE-4322](#)) The engine would crash when aggregate or window functions were used in a recursive query.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4321](#)) Regression: *isql* was not destroying the SQL statement.

fixed by A. Peshkov

~ ~ ~

([CORE-4319](#)) The engine would crash when the Trace config contained the line “connection_id=NN” and an attempt was made to connect to a non-existent database or alias.

fixed by V. Khorsun

~ ~ ~

([CORE-4304](#)) The engine would crash when an attempt to REcreate a table with a foreign key was made after a syntax error that preceded the RECREATE attempt.

fixed by A. dos Santos Fernandes

~ ~ ~

API/Remote Interface

([CORE-4275](#)) CREATE DATABASE would fault if `fbclient.dll` was loaded from another directory (Providers = Engine12).

fixed by V. Khorsun

~ ~ ~

Utilities

isql

([CORE-4480](#)) *isql* would issue the warning “Bad debug info format” when connecting to a database with stored functions after a restore.

fixed by D. Yemanov

~ ~ ~

([CORE-4440](#)) *isql* would crash without connecting when executing the command SHOW VERSION.

fixed by A. Peshkov

~ ~ ~

([CORE-4380](#)) *isql* would truncate a BLOB when reading an empty segment.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4320](#)) Regression: *isql* would crash when receiving statistics from the execution of a SQL query.

fixed by V. Khorsun

~ ~ ~

gbak

([CORE-4470](#)) *gbak* restore would fail on a database containing dependency between views and packaged functions.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4425](#)) User collations based on UNICODE were not being upgraded to a newer ICU version on restore.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4417](#)) *gbak* refused to commit the index for a primary key with characters accented with an umlaut.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4346](#)) V.3 *gbak* was unable to restore backups made on earlier server versions.

fixed by D. Yemanov

~ ~ ~

nBackup

([CORE-4461](#)) *nBackup* was printing error messages to *stdout* instead of *stderr*.

fixed by A. Peshkov

~ ~ ~

qli

([CORE-4327](#)) *qli* was throwing an error when copying NULL blobs between databases.

fixed by A. Peshkov

~ ~ ~

Firebird 3.0 Second Alpha Release

The following improvements and bug fixes were reported as fixed prior to the v.3.0.0 release:

Core Engine

([CORE-4302](#)) Descending index could be very inefficient for some keys

fixed by V. Khorsun

~ ~ ~

([CORE-4289](#)) A NOT NULL field from a derived table could become NULL when referred to from outside the derived table

fixed by D. Yemanov

~ ~ ~

([CORE-4281](#)) TYPE OF arguments of stored functions could cause the server to hang if depending on a domain or column that had been changed

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4270](#)) A subquery involving a windowed function and a where `<field> IN(select ...)` condition could cause an error

fixed by D. Yemanov

~ ~ ~

([CORE-4265](#)) An unexpected lock conflict error could be raised while connecting to a heavily loaded database

fixed by D. Yemanov

~ ~ ~

([CORE-4262](#)) Context parsing errors could occur with derived tables and CASE functions

fixed by D. Yemanov

~ ~ ~

([CORE-4261](#)) JOIN result could be wrong when joined fields had been created via the `row_number ()` function

fixed by D. Yemanov

~ ~ ~

([CORE-4258](#)) The boundary for the minimum value for BIGINT/DECIMAL(18) was wrong

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4251](#)) The Guardian service could write garbage after the end of a message in the Event Log

fixed by V. Khorsun

~ ~ ~

([CORE-4250](#)) Access violation could occur in Guardian at process shutdown

fixed by V. Khorsun

~ ~ ~

([CORE-4237](#)) Metadata being reported from system table queries for UDF return arguments was different to that returned in Firebird 2.5

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4234](#)) `IF (subfunc ())` would throw an error when subfunc returned a Boolean

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4229](#)) Bidirectional cursor was not being positioned by the first call of `FETCH LAST`

fixed by D. Yemanov

~ ~ ~

([CORE-4227](#)) A parser conflict was causing wrong evaluation of BETWEEN and Boolean expressions
fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4216](#)) Memory leak with TRIGGER ON TRANSACTION COMMIT
fixed by V. Khorsun

~ ~ ~

([CORE-4211](#)) The embedded engine would hang for 5 seconds when closing, with errors about timeout in shutdown process and invalid mutex being written into `firebird.log`
fixed by A. Peshkov

~ ~ ~

([CORE-4201](#)) A computed field would return NULL inside a BEFORE INSERT trigger
fixed by D. Yemanov

~ ~ ~

([CORE-4198](#)) An incorrect “token unknown” error would occur when an SQL string ended with a hex number literal
fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4177](#)) Some Boolean expressions were not being allowed
fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4159](#)) Incorrect memory statistics were being reported
fixed by D. Yemanov

~ ~ ~

([CORE-4156](#)) RDB\$GET_CONTEXT/RDB\$SET_CONTEXT parameters were being described incorrectly as CHAR NOT NULL instead of VARCHAR NULLABLE
fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3689](#)) Bad performance and slow response were exhibited when many concurrent sorts were executed
fixed by D. Yemanov

~ ~ ~

([CORE-3291](#)) With **bugcheckabort=1** and sweep starting at gap ~21000, “Bugcheck 186 (record disappeared)” and 100% CPU load would occur

fixed by V. Khorsun

~ ~ ~

([CORE-2165](#)) Unnecessary index reads could occur when using a strict inequality condition

fixed by V. Khorsun

~ ~ ~

Server Crashes

([CORE-4293](#)) The server could crash on a SELECT with a long or complex list of compound AND/OR'd predicates

fixed by D. Yemanov

~ ~ ~

([CORE-4271](#)) Recreation of an errant package body could cause the engine to crash

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4268](#)) Disconnecting from a database could cause a server crash

fixed by D. Yemanov

~ ~ ~

([CORE-4267](#)) Sweeping a database could cause a server crash

fixed by D. Yemanov

~ ~ ~

([CORE-4225](#)) The server could crash when trace activity was attempted on a database having a database-level trigger

fixed by V. Khorsun

~ ~ ~

([CORE-4185](#)) Server crashes could occur, reporting “invalid lock id (NNNNN)”

fixed by A. Peshkov

~ ~ ~

API/Remote Interface

([CORE-4283](#)) “Resource temporarily unavailable” errors could occur while events were being registered simultaneously

fixed by A. Peshkov

~ ~ ~

([CORE-4236](#)) Database shutdown was being reported as successfully completed before all active connections had actually been interrupted

fixed by D. Yemanov

~ ~ ~

([CORE-4178](#)) The new API was still returning obscure historical definition artifacts of data fields, instead of proper metadata properties that would make the interface actually usable

fixed by A. Peshkov

~ ~ ~

([CORE-4162](#)) Warnings were not being returned from calls to **attachDatabase()**

fixed by A. Peshkov

~ ~ ~

Security/User Management

([CORE-4241](#)) Log-in could succeed with an empty password

fixed by A. Peshkov

~ ~ ~

([CORE-4200](#)) An uncommitted SELECT from the pseudo table `sec$users` would block new database connections

fixed by A. Peshkov

~ ~ ~

Procedural Language

([CORE-4247](#)) Positioned DELETE (WHERE CURRENT OF <CURSOR>) could fail for tables with newly added fields

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4244](#)) Creating a procedure could be a problem if it involved adding text in DOS864 character set
fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4184](#)) An error would be raised while executing an empty EXECUTE BLOCK with NOT NULL output parameter
fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4160](#)) A parameterized exception would mishandle non-ASCII characters passed as the parameter
fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4145](#)) Preparing an EXECUTE BLOCK that used domains was causing a memory leak
fixed by A. dos Santos Fernandes

~ ~ ~

Data Definition Language

([CORE-4214](#)) Global temporary tables were able to reference permanent relations, which they should not be able to do
fixed by V. Khorsun

~ ~ ~

([CORE-4212](#)) Dropping a foreign key on a Global temporary table would cause a server crash
fixed by V. Khorsun

~ ~ ~

([CORE-4203](#)) Packaged routines with CHAR or VARCHAR parameters could not be created
fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4180](#)) CREATE COLLATION was not verifying the base collation character set
fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4173](#)) Setting a generator value twice in a single transaction would set it to zero
fixed by D. Yemanov

~ ~ ~

([CORE-4155](#)) External routines DDL in packages was wrongly reporting termination with semi-colon as an error

fixed by A. dos Santos Fernandes

~ ~ ~

Data Manipulation Language

([CORE-4269](#)) Wrong output would be produced when a field with the result of a windowed function was used in a query with a useless WHERE 0=0 and GROUP BY clause

fixed by D. Yemanov

~ ~ ~

([CORE-4255](#)) Parameterized queries using RDB\$DB_KEY would not work

fixed by D. Yemanov

~ ~ ~

([CORE-4240](#)) Recursive query would return incorrect results if passage through more than one branch was requested

fixed by D. Yemanov

~ ~ ~

([CORE-4158](#)) LIKE with escape was not working

fixed by A. dos Santos Fernandes

~ ~ ~

Utilities

gfix

([CORE-4297](#)) gfix would crash when the size of the description of a limbo transaction was larger than 1 KB

fixed by V. Khorsun

~ ~ ~

fbsvcmgr

([CORE-4298](#)) fbsvcmgr was not recognising *sts_record_versions* and other *sts* switches

fixed by A. Peshkov

~ ~ ~

isql

([CORE-4259](#)) Bug in the `isql` command `setlocale(LC_CTYPE, "")` on Windows due to a reference to `editline`, which is not available on that platform

fixed by F. Schlottmann-Goedde

~ ~ ~

([CORE-4205](#)) **ISQL -x** was failing to output the START WITH clause of generators/sequences

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4149](#)) New permission types were not being displayed by `isql`

fixed by D. Yemanov

~ ~ ~

([CORE-362](#)) It was impossible to enter certain characters in `isql`

fixed by F. Schlottmann-Goedde

~ ~ ~

gbak

([CORE-4202](#)) Backup/restore from an older version to v.3.0 would fail with a BLR error

fixed by D. Yemanov

~ ~ ~

([CORE-4168](#)) A backup containing procedures or triggers that selected from external tables could not be restored with **ExternalFileAccess = None**

fixed by D. Yemanov

~ ~ ~

([CORE-4164](#)) Owner name was missing for generators and exceptions restored from a backup

fixed by D. Yemanov

~ ~ ~

nbackup

([CORE-2648](#)) `nBackup`'s delta file was ignoring the Forced Writes setting of the database

fixed by V. Khorsun

~ ~ ~

Database Monitoring (MON\$)

([CORE-4235](#)) Deadlock could occur while accessing the monitoring tables under concurrent load

fixed by D. Yemanov & V. Khorsun

~ ~ ~

([CORE-4176](#)) Monitoring tables were returning incomplete information in Classic and Superclassic configurations

fixed by D. Yemanov

~ ~ ~

Trace

([CORE-4219](#)) Regular expressions with double-slash would fail in trace

fixed by A. Peshkov

~ ~ ~

([CORE-4163](#)) Configuration file `fbtrace.conf` contained syntax errors

fixed by A. Peshkov

~ ~ ~

International Language Support

Installation Issues

([CORE-4153](#)) Attempting to use `Legacy_Auth` directly after install would not work without restarting the service

fixed by P. Reeves

~ ~ ~

Firebird 3.0 First Alpha Release

The following improvements and bug fixes were reported as fixed prior to the v.3.0.0 release:

Core Engine

([CORE-4135](#)) Sweep was blocking the establishment of concurrent attachments in Superserver.

fixed by V. Khorsun

~ ~ ~

([CORE-4134](#)) A race condition could occur when auto-sweep was started.

fixed by V. Khorsun

~ ~ ~

([CORE-4074](#)) COMPUTED BY columns and POSITION function could produce garbled results.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-4027](#)) Creating a table with computed fields containing SELECT FIRST could produce a corrupted result.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3973](#)) The SQLDA for an aliased column in a grouped query was missing the original table name, column name and owner.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3947](#)) Wrong results were produced when a column in the WHERE clause used the collation option (NUMERIC-SORT=1).

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3941](#)) A unique expression index would exhibit a memory alignment problem.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3929](#)) The invalid error “attempted update of read-only column” would appear when selecting MINVALUE from a list of more than 255 elements.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3894](#)) When an attempt was made to reduce the size of a CHAR or VARCHAR column, the numbers delivered in the error message were incorrect.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3874](#)) A computed column would appear in non-existent rows output from a left join.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3820](#)) Some character sets were duplicated in the system table RDB\$TYPES.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3754](#)) SIMILAR TO was not working correctly.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3735](#)) An unprivileged user could delete from the system tables RDB\$DATABASE, RDB\$COLLATIONS and RDB\$CHARACTER_SETS.

fixed by D. Yemanov

~ ~ ~

([CORE-3694](#)) “Internal consistency check” would occur in a query with grouping by subquery+stored procedure+aggregate.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3672](#)) It was not possible to use the SUBSTRING function to create a computed index for large columns.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3638](#)) Some collation tweaking: FR_CA_CI_AI collation was introduced; FR_FR was changed to be identical to FR_CA and FR_FR_CI_AI was changed to be identical to the new FR_CA_CI_AI.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3476](#)) The LIST function was concatenating binary blobs as though they were text.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3401](#)) Collation errors could occur with the use of **[type of] <domain>** and **type of <column>**.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3373](#)) It was possible to store a string of length 31 characters into a VARCHAR(25) column.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3338](#)) *Regression:* Code changes had disabled support for expression indexes with COALESCE, CASE and DECODE.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3317](#)) Success of row deletion depended on the order of insertion of the rows.

fixed by V. Khorsun

~ ~ ~

([CORE-3310](#)) A complex expression involving RDB\$GET_CONTEXT and BETWEEN worked in DSQL but failed with a conversion error when selected in a view definition.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3260](#)) Interlock.h was not portable.

fixed by A. Peshkov

~ ~ ~

([CORE-3250](#)) The Firebird server could not be started under any user name other than “root”, “firebird”, “interbas” or “interbase”.

fixed by A. Peshkov

~ ~ ~

([CORE-3239](#)) The collation UTF8 UNICODE_CI could not be used in a compound index.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3204](#)) A constraint violation error involving CAST was not being raised inside views.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3052](#)) Comparisons involving multiple index segments could produce wrong result sets.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-2988](#)) The concurrent transaction number was not being reported when a lock timeout occurred.

fixed by N. Samofatov

~ ~ ~

([CORE-2957](#)) COUNT(*) from a big table could return a negative result.

fixed by D. Yemanov

~ ~ ~

([CORE-2952](#)) Character class names in SIMILAR TO expressions could be case-sensitive or case-insensitive, depending on the collation of the left part, whereas they should be unequivocally case-insensitive.

fixed by D. Sibiriyakov

~ ~ ~

([CORE-2932](#)) An ALTER TABLE..ALTER COLUMN..ALTER POSITION operation could result in wrong column positions.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-2922](#)) The character set used in a constant was not being registered as a dependency.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-2913](#)) COLLATE expressions were being applied incorrectly.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-2798](#)) Plan output lacked the names of views when selecting from views that contained procedure calls.

fixed by D. Yemanov

~ ~ ~

([CORE-2796](#)) DB_KEY was always zero for rows in external tables.

fixed by D. Yemanov

~ ~ ~

([CORE-2678](#)) A full outer join could not use available indices, resulting in very slow execution sometimes.

fixed by D. Yemanov

~ ~ ~

([CORE-2508](#)) Use of certain choices of character in double-quoted index names, for example a bracket character, could defeat the parsing logic when generating a human-readable plan.

fixed by D. Yemanov

~ ~ ~

([CORE-2155](#)) A join of a stored procedure with a view or a table could fail with the error “No current record for fetch operation”.

fixed by D. Yemanov

~ ~ ~

([CORE-1712](#)) A buffer overrun error was being caught erroneously in a DOUBLE PRECISION to VARCHAR conversion in a Dialect 1 database.

fixed by C. Valderrama C.

~ ~ ~

([CORE-1605](#)) An aggregated query was causing “Bugcheck 232 (invalid operation)”.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-1550](#)) An unnecessary index scan was executed when the same index is mapped to both WHERE and ORDER BY clauses.

fixed by D. Yemanov

~ ~ ~

API/Remote Interface

([CORE-3718](#)) The client library could hang after an unsuccessful attempt to connect to the remote auxiliary (events) port.

fixed by A. Peshkov

~ ~ ~

([CORE-3475](#)) Parameters inside the CAST function were being wrongly described in the SQLDA as non-nullable.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3269](#)) The client would perform *detach* incorrectly when the server became unavailable.

fixed by A. Peshkov

~ ~ ~

([CORE-2484](#)) An erroneous “Success” message would be returned in the error status vector when failing to connect to a trash database file.

fixed by C. Valderrama C.

~ ~ ~

([CORE-2431](#)) String values in error messages were not converted to the connection character set.

fixed by A. dos Santos Fernandes

~ ~ ~

Procedural Language

([CORE-4018](#)) Use of a system domain in declarations of arguments or return values in a stored procedure could prevent the procedure from being modifiable.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3737](#)) EXECUTE BLOCK parameter definitions were not being respected and could cause wrong behavior with respect to character sets.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3545](#)) Validation of domain CHECK constraints when used in PSQL declarations was inconsistent: it was using the type of the expression, instead of the type of the variable.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3055](#)) The names of variables or arguments could be wrong or absent in error messages when more than 256 variables were used.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3047](#)) Resolution of EXECUTE BLOCK parameter collations was using wrong logic.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-2204](#)) Constraints on stored procedure output parameters were checked even when the procedure returned no rows.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-1620](#)) Incorrect error message (an absurd column number) was returned if an empty SQL string was prepared for EXECUTE STATEMENT.

fixed by D. Yemanov

~ ~ ~

Data Definition Language

([CORE-3114](#)) Attempting to drop a non-existent generator (sequence) would result in a serious exception.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3056](#)) Problems could occur if further DDL commands were issued in the same transaction following a CREATE COLLATION command.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-2696](#)) The ALTER TABLE command allowed the addition of a column with a NOT NULL definition, allowing a non-savvy DBAdmin to wreck the table.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-1748](#)) Unrestorable backup: a problem which would occur if ALTER TABLE...ADD COLUMN added a column with a NOT NULL constraint. The fix for [CORE-2696](#) has now made it impossible to do this.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-1518](#)) Adding a non-nullable column to a populated table would render the table inconsistent. The fix for [CORE-2696](#) has now made it impossible to do this.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-1355](#)) Client tools tended to be confused about how to interpret a NULL that is returned from a non-nullable column. The fix for [CORE-2696](#) has now made it impossible to add a non-nullable column to a populated table.

It is not clear, though, whether this part of the fix makes it mandatory to specify a default value for a non-nullable column.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-634](#)) Bad behaviour of DELETE when the WHERE clause was a subquery involving FIRST/SKIP: the operation would zap every row in the table.

fixed by V. Khorsun

~ ~ ~

([CORE-304](#)) Any user could alter or drop generators and exceptions#a metadata security hole.

fixed by D. Yemanov

~ ~ ~

Data Manipulation Language & DSQL

([CORE-4144](#)) When when preparing a query with UNION, the error “context already in use (BLR error)” was wrongly being thrown.

fixed by V. Khorsun

~ ~ ~

([CORE-4005](#)) Recursive CTEs were returning a wrong error message.

fixed by V. Khorsun

~ ~ ~

([CORE-3416](#)) Inserting a word containing the 8-bit character 'ä' into a CHARACTER SET ASCII column would succeed instead of throwing a transliteration error.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3201](#)) The internal function ATAN2 was returning an incorrect value with arguments (0, 0).

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3174](#)) An expression index involving TRIM could lead to an incorrect indexed lookup.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-2699](#)) A common table expression context could be used with parameters.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-2606](#)) A multi-byte CHAR value requested as VARCHAR was returned with padded spaces.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-2238](#)) With UTF8 and large varchar fields, IS DISTINCT FROM would cause the error “Implementation limit exceeded”.

fixed by D. Yemanov

~ ~ ~

([CORE-1188](#)) STARTING WITH ? (where the parameter value supplied is an empty string) would fail if the plan used a compound index.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-92](#)) Infinite insertion cycle: INSERT INTO THIS_TABLE SELECT ... FROM THIS_TABLE would loop forever until resources were exhausted.

fixed by V. Khorsun

~ ~ ~

Command-line Utilities

([CORE-2547](#)) Utilities did not always honour the minimum number of characters required to recognise an option.

fixed by C. Valderrama C.

~ ~ ~

Other old bugs that were fixed in utilities:

FbGuard

([CORE-2784](#)) Guardian would keep creating more and more threads each time FBServer died.

fixed by C. Valderrama C.

~ ~ ~

([CORE-1595](#)) Firebird Guardian's tray icon would disappear after a Windows Explorer crash.

fixed by C. Valderrama C.

~ ~ ~

isql

([CORE-4137](#)) *isql* was generating metadata script output with syntax errors in the CHARACTER SET clause, e.g., CHARACTER SETISO8859_1.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-3431](#)) *isql* was padding UTF-8 data incorrectly.

fixed by A. dos Santos Fernandes

~ ~ ~

([CORE-2788](#)) *isql* would extract the array dimensions after the character set name.

fixed by C. Valderrama C.

~ ~ ~

gbak

([CORE-3575](#)) *gbak* did not support backup volumes of size greater than 4GB.

fixed by A. Peshkov

~ ~ ~

([CORE-2740](#)) *gbak* would restore invalid views without any warning to the user.

fixed by C. Valderrama C.

~ ~ ~

([CORE-2545](#)) Several validations were lacking in *gbak*.

fixed by C. Valderrama C.

~ ~ ~

nbackup

([CORE-2543](#)) *nbackup* could hide the real cause of a failure.

fixed by C. Valderrama C.

~ ~ ~

International Language Support

([CORE-4136](#)) The “Sharp-S” character was being treated incorrectly in the UNICODE_CI_AI collation.

fixed by A. dos Santos Fernandes

~ ~ ~

Chapter 13

Firebird 3.0 Project Teams

Table 13.1. Firebird Development Teams

Developer	Country	Major Tasks
Dmitry Yemanov	Russian Federation	Full-time database engineer/implementor, core team leader
Alex Peshkov	Russian Federation	Full-time security features coordinator; buildmaster; porting authority
Claudio Valderrama	Chile	Code scrutineer; bug-finder and fixer; ISQL enhancements; UDF fixer, designer and implementor
Vladyslav Khorsun	Ukraine	Full-time DB engineer, SQL feature designer/implementor
Adriano dos Santos Fernandes	Brazil	International character-set handling; text and text BLOB enhancements; new DSQL features; code scrutineering
Roman Simakov	Russian Federation	Engine contributions
Paul Beach	France	Release Manager; HP-UX builds; MacOS Builds; Solaris Builds
Pavel Cisar	Czech Republic	QA tools designer/coordinator
Philippe Makowski	France	QA tester
Paul Reeves	France	Win32 installers and builds
Mark Rotteveel	The Netherlands	Jaybird implementor and co-coordinator
Jiri Cincura	Czech Republic	Developer and coordinator of .NET providers
Alexander Potapchenko	Russian Federation	Developer and coordinator of ODBC/JDBC driver for Firebird
Stephen Boyd	Canada	GPRED contributions
Alexey Kovyazin	Russian Federation	Website coordinator
Paul Vinkenoog	The Netherlands	Coordinator, Firebird documentation project; documentation writer and tools developer/implementor
Norman Dunbar	U.K.	Documentation writer

Developer	Country	Major Tasks
Pavel Menshchikov	Russian Federation	Documentation translator
Tomneko Hayashi	Japan	Documentation translator
Umberto (Mimmo) Masotti	Italy	Documentation translator
Helen Borrie	Australia	Release notes editor; Chief of Thought Police

Appendix A: Licence Notice

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The Original Documentation is entitled *Firebird 3.0 Release Notes*.

The Initial Writer of the Original Documentation is: Helen Borrie. Persons named in attributions are Contributors.

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