MySQL Connector/NET Developer Guide

Abstract

This manual describes how to install and configure MySQL Connector/NET, the connector that enables .NET applications to communicate with MySQL servers, and how to use it to develop database applications.

For notes detailing the changes in each release of Connector/NET, see MySQL Connector/NET Release Notes.

For legal information, including licensing information, see the Preface and Legal Notices.

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

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Chapter 1 Introduction to MySQL Connector/NET

MySQL Connector/NET enables you to develop .NET applications that require secure, high-performance data connectivity with MySQL. It implements the required ADO.NET interfaces and integrates into ADO.NET-aware tools. You can build applications using your choice of .NET languages. Connector/NET is a fully managed ADO.NET data provider written in 100% pure C#. It does not use the MySQL C client library.

Connector/NET source code and tests are available from the NuGet Gallery and GitHub. For notes detailing the changes in each release of Connector/NET, see MySQL Connector/NET Release Notes.

Connector/NET includes full support for:

- Features provided by MySQL Server, up to and including the MySQL 8.1 release series.
- MySQL as a document store (NoSQL), along with X Protocol connection support to access MySQL data using X Plugin ports.
- Large-packet support for sending and receiving rows and `BLOB` values up to 2 gigabytes in size.
- Protocol compression, which enables compressing the data stream between the client and server.
- Connections using TCP/IP sockets, named pipes, or shared memory on Windows.
- Connections using TCP/IP sockets or Unix sockets on Unix.
- Encrypted connections using:
  - TLSv1.2 protocol over TCP/IP with Connector/NET 8.0.11 and later.
  - TLSv1.3 protocol over TCP/IP with Connector/NET 8.0.20 and later.
- .NET Standard and runs on the Universal Windows Platform (UWP) .NET implementation.
- Entity Framework 6 and Entity Framework Core to migrate data to and from MySQL data tables.
- The Open Source Mono framework developed by Novell.

Connector/NET supports Microsoft Visual Studio 2013, 2015, 2017, and 2019, although the extent of support may be limited depending on the versions of Connector/NET and Visual Studio you use. For details, see Chapter 2, *Connector/NET Versions*.

Key Topics

- For connection string properties when using the `MySqlConnection` class, see Section 4.5, “Connector/NET Connection Options Reference”.

Chapter 2 Connector/NET Versions

MySQL Connector/NET 8.1 is a continuation of Connector/NET 8.0, but now named to synchronize with the (latest) MySQL server version it supports. This version combines the functionality of the previous Connector/NET release series, including support for X Protocol connections. Connector/NET customizes Entity Framework Core to operate with MySQL data, enables compression in the .NET driver implementation, and extends cross-platform support to Linux and macOS.

Secure connections using the TLSv1.2 protocol require Connector/NET 8.0.11 or later. In addition, your Microsoft Windows host must have the TLSv1.2 protocol enabled. Connections made using Windows named pipes or shared memory do not support the TLSv1.2 protocol. For general guidance about configuring the server and clients for secure connections, see Configuring MySQL to Use Encrypted Connections.

> **Note**
>
> .NET 7, .NET 6, and .NET Framework 4.8 (Windows only) include support for the TLSv1.3 protocol. Be sure to confirm that the operating system running your application also supports TLSv1.3 before using it exclusively for connections.

The following table shows the versions of ADO.NET, .NET (Core and Framework), and MySQL Server that are supported or required by MySQL Connector/NET. For the specific Entity Framework versions that Connector/NET targets, see Chapter 7, *Connector/NET for Entity Framework*.

Table 2.1 Connector/NET Requirements for Related Products

Connector/NET Version	ADO.NET Version	.NET Versions and Visual Studio	MySQL Server
8.1.0	2.x+	For apps that target .NET 7, use VS 2022 (v17.4 or later) For apps that target .NET 6, use VS 2022 (v17.0 and later) or VS 2022 for Mac (v17.6 or later) For apps that target .NET Framework 4.8, use VS 2019 (v16.3 or later)	MySQL 8.1, MySQL 8.0, and MySQL 5.7

Archived Connector/NET versions and their requirements:

- C/NET 8.0.33: .NET 7, use VS 2022 (v17.4 or later) | .NET 6, use VS 2022 (v17.0) or VS 2022 for Mac (v17.0 preview) | .NET Core 3.1, use VS 2019 (v16.4 or later) | .NET Framework 4.8, use VS 2019 (v16.3 or later)

  Recommended minimum server version: MySQL 8.0.33 or MySQL 5.7.42

- C/NET 8.0.28+: .NET 6, use VS 2022 (v17.0 or later) or VS 2019 for Mac (v8.10) | .NET 5, use VS 2019 (v16.8) or VS 2019 for Mac (v8.8) | .NET Core 3.1, use VS 2019 (v16.4 or later) | .NET Framework 4.8, use VS 2019 (v16.3 or later)

  Recommended minimum server version: MySQL 8.0.28 or MySQL 5.7.37

- C/NET 8.0.23+: .NET 5, use VS 2019 (v16.8) or VS 2019 for Mac (v8.8) | .NET Core 3.1, use VS 2019 (v16.4 or later) | .NET Framework 4.8, use VS 2019 (v16.3 or later)

  Recommended minimum server version: MySQL 8.0.23 or MySQL 5.7.33

- C/NET 8.0.22+: .NET 5, use VS 2019 (v16.7) or VS 2019 for Mac (v8.7) | .NET Core 3.1, use VS 2019 (v16.4 or later) | .NET Framework 4.8, use VS 2019 (v16.3 or later)

  Recommended minimum server version: MySQL 8.0.22 or MySQL 5.7.32

- C/NET 8.0.20+: .NET Core 3.1, use VS 2019 (v16.4 or later) | .NET Framework 4.8, use VS 2019 (v16.3 or later)

  Recommended minimum server version: MySQL 8.0.20 or MySQL 5.7.30

- C/NET 8.0.19+: .NET Core 3.0, use VS 2019 (v16.3 or later) | .NET Framework 4.8, use VS 2019 (v16.3 or later)

  Recommended minimum server version: MySQL 8.0.19 or MySQL 5.7.29

- C/NET 8.0.18+: .NET Core 3.0, use VS 2019 (v16.3 or later)

  Recommended minimum server version: MySQL 8.0.18 or MySQL 5.7.28

- C/NET 8.0.17+: .NET Core 2.2, use VS 2017 (v15.0.9 or later) | .NET Core 2.1, use VS 2017 (v15.0.7 or later)

  Recommended minimum server version: MySQL 8.0.17 or MySQL 5.7.27

- C/NET 8.0.10+: .NET Core 2.0, use VS 2017 (v15.0.3 or later)

  Recommended minimum server version: MySQL 8.0.17 or MySQL 5.7.27

- C/NET 8.0.8+: .NET Framework 4.5.x, use VS 2013 / 2015 / 2017

  Recommended minimum server version: MySQL 8.0.17 or MySQL 5.7.27

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MySQL Connector/NET runs on any platform that supports the .NET Standard (.NET Framework, .NET Core, and Mono). The .NET Framework is primarily supported on recent versions of Microsoft Windows and Microsoft Windows Server.

Cross-platform options:

- .NET Core provides support on Windows, macOS, and Linux.
- Open Source Mono platform provides support on Linux.

Connector/NET is available for download as a standalone MSI Installer or from the NuGet gallery. The source code is available for download from MySQL Download MySQL Connector/NET or at GitHub from the MySQL Connector/NET repository.

> **Note**
>
> Starting with Connector/NET 8.0.33, application developers must ensure the availability of following libraries at run time. Previously, the libraries were bundled with Connector/NET installations.
>
> For applications using OCI Authentication and SSL Certificates validation:
>
> - `Portable.BouncyCastle` (see https://www.nuget.org/packages/Portable.BouncyCastle)
>
> For applications using X DevAPI:
>
> - `K4os.Compression.LZ4.Streams` (see https://www.nuget.org/packages/K4os.Compression.LZ4.Streams)
> - `Google.Protobuf` (see https://www.nuget.org/packages/Google.Protobuf)

3.1 Installing Connector/NET on Windows

On Microsoft Windows, you can install either through a binary installation process using a Connector/NET MSI, using NuGet, or by downloading and using the source code.

Before installing, ensure that your system is up to date, including installing the latest version of the .NET Framework or .NET Core. For additional information, see Chapter 2, *Connector/NET Versions*.

3.1.1 Installing Connector/NET Using the Standalone Installer

You can install MySQL Connector/NET through a Windows Installer (`.msi`) installation package, which can install Connector/NET on supported Windows operating systems. The MSI package is a file named `mysql-connector-net-`*`version`*`.msi`, where *`version`* indicates the Connector/NET version.

To install Connector/NET:

1. Double-click the MSI installer file, and click **Next** to start the installation.
2. Choose the type of installation to perform (Typical, Custom, or Complete) and then click **Next.**
   - The typical installation is suitable in most cases. Click **Typical** and proceed to Step 5.
   - A Complete installation installs all the available files. To conduct a Complete installation, click the **Complete** button and proceed to step 5.
   - To customize your installation, including choosing the components to install and some installation options, click the **Custom** button and proceed to Step 3.

   The Connector/NET installer will register the connector within the Global Assembly Cache (GAC) - this will make the Connector/NET component available to all applications, not just those where you explicitly reference the Connector/NET component. The installer will also create the necessary links in the Start menu to the documentation and release notes.
3. If you have chosen a custom installation, you can select the individual components to install, including the core interface component, supporting documentation options, examples, and the source code. Click **Disk Usage** to determine the disk-space requirements of your component choices.

   Select the items and their installation level and then click **Next** to continue the installation.
4. You will be given a final opportunity to confirm the installation. Click **Install** to copy and install the files onto your computer. Use **Back** to return to the modify your component options.
5. When prompted, click **Finish** to exit the MSI installer.

Unless you choose a different folder, Connector/NET is installed in `C:\Program Files (x86)\MySQL\MySQL Connector Net` *`version`* (the version installed). New installations do not overwrite existing versions of Connector/NET.

You may also use the `/quiet` or `/q` command-line option with the `msiexec` tool to install the Connector/NET package automatically (using the default options) with no notification to the user. Using this method the user cannot select options. Additionally, no prompts, messages or dialog boxes will be displayed.

```
C:\> msiexec /package connector-net.msi /quiet
```

To provide a progress bar to the user during automatic installation, use the `/passive` option.

3.1.2 Installing Connector/NET Using NuGet

MySQL Connector/NET functionality is available as packages from NuGet, an open-source package manager for the Microsoft development platform (including .NET Core). The NuGet Gallery is the central software package repository populated with the most recent NuGet packages for Connector/NET.

You can install or upgrade one or more individual Connector/NET packages with NuGet, making it a convenient way to introduce existing technology, such as Entity Framework, to your project. NuGet manages dependencies across the related packages and all of the prerequisites are listed in the NuGet Gallery. For a description of each Connector/NET package, see Connector/NET Packages (NuGet).

> **Important**
>
> For projects that require Connector/NET assemblies to be stored in the GAC or integration with Entity Framework Designer (Visual Studio), use the standalone MSI to install Connector/NET, rather than installing the NuGet packages.

Consuming Connector/NET Packages with NuGet

The NuGet Gallery (https://www.nuget.org/) provides several client tools that can help you install or upgrade Connector/NET packages. If you are not familiar with the tool options or processes, see Package consumption workflow to get started. After locating a package description in NuGet, confirm the following information:

- The identity and version number of the package are correct. Use the **Version History** list to select the current version.
- All of the prerequisites are installed. See the **Dependencies** list for details.
- The license terms are met. See the **License Info** link to view this information.

Connector/NET Packages (NuGet)

Connector/NET provides the following five NuGet packages:

`MySql.Data` — This package contains the core functionality of Connector/NET, including using MySQL as a document store (with Connector/NET 8.0 only). It implements the required ADO.NET interfaces and integrates with ADO.NET-aware tools. In addition, the packages provides access to multiple versions of MySQL server and encapsulates database-specific protocols.

`MySql.Web` — The `MySql.Web` package includes support for the ASP.NET 2.0 provider model (see Section 6.2, “ASP.NET Provider Model and Tutorials”). This model enables you to focus on the business logic of your application, rather than having to recreate boilerplate items such as membership and roles support. The package supports the membership, role, profile, and session-state providers.

Package dependency: `MySql.Data`.

`MySql.Data.EntityFramework` — This package provides object-relational mapper (ORM) capabilities, which enables you to work with MySQL databases using domain-specific objects, thereby eliminating the need for most of the data access code. Select this package for your Entity Framework 6 applications (see Section 7.1, “Entity Framework 6 Support”).

Package dependency: `MySql.Data`.

`MySql.Data.EntityFrameworkCore` — This package is similar to the `MySql.Data.EntityFramework` package; however, it provides multi-platform support for Entity Framework tasks. Select this package for your Entity Framework Core applications (see Section 7.2, “Entity Framework Core Support”).

`MySql.Data.EntityFrameworkCore.Design` — The `MySql.Data.EntityFrameworkCore.Design` package includes shared design-time components for Entity Framework Core tools, which enable you to scaffold and migrate MySQL databases.

> **Note**
>
> Beginning with Connector/NET 8.0.20, the functionality provided in this package has been relocated to the `MySql.Data.EntityFrameworkCore`

package. The original `MySql.Data.EntityFrameworkCore.Design` package is deprecated.

3.2 Installing Connector/NET on Unix with Mono

There is no installer available for installing the MySQL Connector/NET component on your Unix installation. Before installing, ensure that you have a working Mono project installation. To test whether your system has Mono installed, enter:

```
$> mono --version
```

The version of the Mono JIT compiler is displayed.

To compile C# source code, make sure a Mono C# compiler is installed.

> **Note**
>
> There are three Mono C# compilers available: `mcs`, which accesses the 1.0-profile libraries, `gmcs`, which accesses the 2.0-profile libraries, and `dmcs`, which accesses the 4.0-profile libraries.

To install Connector/NET on Unix/Mono:

1. Download the `mysql-connector-net-`*`version`*`-noinstall.zip` and extract the contents to a directory of your choice, for example: `~/connector-net/`.
2. In the directory where you unzipped the connector to, change into the `bin` subdirectory. Ensure the file `MySql.Data.dll` is present. This filename is case-sensitive.
3. You must register the Connector/NET component, `MySql.Data`, in the Global Assembly Cache (GAC). In the current directory enter the `gacutil` command:

   ```
   #> gacutil /i MySql.Data.dll
   ```

   This will register `MySql.Data` into the GAC. You can check this by listing the contents of `/usr/lib/mono/gac`, where you will find `MySql.Data` if the registration has been successful.

You are now ready to compile your application. You must ensure that when you compile your application you include the Connector/NET component using the `-r:` command-line option. For example:

```
$> gmcs -r:System.dll -r:System.Data.dll -r:MySql.Data.dll HelloWorld.cs
```

The referenced assemblies depend on the requirements of the application, but applications using Connector/NET must provide `-r:MySql.Data` at a minimum.

You can further check your installation by running the compiled program, for example:

```
$> mono HelloWorld.exe
```

3.3 Installing Connector/NET from Source

Building MySQL Connector/NET from the source code enables you to customize build parameters and target platforms such as Linux and macOS. The procedures in this section describe how to build source with Microsoft Visual Studio (Windows or macOS) and .NET Core CLI (Windows, macOS, or Linux).

MySQL Connector/NET source code is available for download from https://dev.mysql.com/downloads/connector/net/. Select `Source Code` from the **Select Operating System** list. Use the **Archive** tab to download a previous version of Connector/NET source code.

Source code is packaged as a ZIP archive file with a name similar to `mysql-connector-net-8.0.19-src.zip`. Unzip the file to local directory.

The file includes the following directories with source files:

- `EFCore`: Source and test files for Entity Framework Core features.
- `EntityFramework`: Source and test files for Entity Framework 6 features.
- `MySQL.Data`: Source and test files for features using the MySQL library.
- `MySQL.Web`: Source and test files for the web providers, including the membership, role, profile providers that are used in ASP.NET or ASP.NET Core websites.

Building Source Code with Visual Studio

The following procedure can be used to build the connector on Microsoft Windows or macOS. Connector/NET supports various versions of Microsoft Visual Studio and .NET libraries. For guidance about the Connector/NET version you intend to build, see Chapter 2, *Connector/NET Versions* before you begin.

1. Navigate to the root of the source code directory and then to the directory with the source files to build, such as `MySql.Data`. Each source directory contains a Microsoft Visual Studio solution file with the `.sln` (for example, `MySqlData.sln`).

2. Double-click the solutions file to start Visual Studio and open the solution.

   Visual Studio opens the solution files in the Solution Explorer. All of the projects related to the solution also appear in the navigation tree. These related projects can include test files and the projects that your solutions requires.

3. Locate the project with the same name as the solution (`MySql.Data` in this example). Right-click the node and select **Build** from the context menu to build the solution.

Building Source Code with .NET Core CLI

The following procedure can be used to build the connector on Microsoft Windows, Linux, or macOS. A current version of the .NET Core SDK must be installed locally to execute `dotnet` commands. For additional usage information, visit https://docs.microsoft.com/en-us/dotnet/core/tools/.

1. Open a terminal such as `PowerShell`, `Command Prompt`, or `bash`.

   Navigate to the root of the source code directory and then to the directory with the source files to build, such as `MySQL.Data`.

2. Clean the output of the previous build.

   ```
   dotnet clean
   ```

3. Type the following command to build the solution file (`MySql.Data.sln` in this example) using the default command arguments:

   ```
   dotnet build
   ```

   Solution and project default. When no directory and file name is provided on the command line, the default value depends on the current directory. If the command is executed from the top directory, such as `MySQL.Data`, the solution file is selected (new with the .NET Core 3.0 SDK). Otherwise, if executed from the `src` subdirectory, the project file is used.

Configuration default, `-c` | `--configuration`. Defaults to the `Debug` build configuration. Alternatively, `-c Release` is the other supported build configuration argument value.

Framework default, `-f` | `--framework`. When no framework is specified on the command line, the solution or project is built for all possible frameworks that apply. To determine which frameworks are supported, use a text editor to open the related project file (for example, `MySql.Data.csproj` in the `src` subdirectory) and search for the `<TargetFrameworks>` element.

To build source code on Linux and macOS, you must target .NET Standard (`-f netstandard2.0` or `-f netstandard2.1`). To build source code on Microsoft Windows, you can target .NET Standard and .NET Framework (`-f net452` or `-f net48`).

Chapter 4 Connector/NET Connections

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All interaction between a .NET application and the MySQL server is routed through a `MySqlConnection` object when using the classic MySQL protocol. Before your application can interact with the server, it must instantiate, configure, and open a `MySqlConnection` object.

Even when using the `MySqlHelper` class, a `MySqlConnection` object is created by the helper class. Likewise, when using the `MySqlConnectionStringBuilder` class to expose the connection options as properties, your application must open a `MySqlConnection` object.

This sections in this chapter describe how to connect to MySQL using the `MySqlConnection` object.

4.1 Creating a Connector/NET Connection String

The `MySqlConnection` object is configured using a connection string. A connection string contains several key-value pairs, separated by semicolons. In each key-value pair, the option name and its corresponding value are joined by an equal sign. For the list of option names to use in the connection string, see Section 4.5, “Connector/NET Connection Options Reference”.

The following is a sample connection string:

```
"server=127.0.0.1;uid=root;pwd=12345;database=test"
```

In this example, the `MySqlConnection` object is configured to connect to a MySQL server at `127.0.0.1`, with a user name of `root` and a password of `12345`. The default database for all statements will be the `test` database.

Connector/NET supports several connection models:

- Opening a Connection to a Single Server
- Opening a Connection for Multiple Hosts with Failover
- Opening a Connection Using a Single DNS Domain

Opening a Connection to a Single Server

After you have created a connection string it can be used to open a connection to the MySQL server.

The following code is used to create a `MySqlConnection` object, assign the connection string, and open the connection.

MySQL Connector/NET can also connect using the native Windows authentication plugin. See Section 4.4, “Connector/NET Authentication” for details.

You can further extend the authentication mechanism by writing your own authentication plugin. See Section 5.8, “Writing a Custom Authentication Plugin” for details.

C# Example

```
MySql.Data.MySqlClient.MySqlConnection conn;
string myConnectionString;

myConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test";

try
{
    conn = new MySql.Data.MySqlClient.MySqlConnection();
    conn.ConnectionString = myConnectionString;
    conn.Open();
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show(ex.Message);
}
```

Visual Basic Example

```
Dim conn As New MySql.Data.MySqlClient.MySqlConnection
Dim myConnectionString as String

myConnectionString = "server=127.0.0.1;" _
            & "uid=root;" _
            & "pwd=12345;" _
            & "database=test"

Try
  conn.ConnectionString = myConnectionString
  conn.Open()

Catch ex As MySql.Data.MySqlClient.MySqlException
  MessageBox.Show(ex.Message)
End Try
```

You can also pass the connection string to the constructor of the `MySqlConnection` class:

C# Example

```
MySql.Data.MySqlClient.MySqlConnection conn;
string myConnectionString;

myConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test";

try
{
    conn = new MySql.Data.MySqlClient.MySqlConnection(myConnectionString);
    conn.Open();
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show(ex.Message);
}
```

Visual Basic Example

```
Dim myConnectionString as String

myConnectionString = "server=127.0.0.1;" _
             & "uid=root;" _
```

```
            & "pwd=12345;" _
            & "database=test"

Try
    Dim conn As New MySql.Data.MySqlClient.MySqlConnection(myConnectionString)
    conn.Open()
Catch ex As MySql.Data.MySqlClient.MySqlException
   MessageBox.Show(ex.Message)
End Try
```

After the connection is open, it can be used by the other Connector/NET classes to communicate with the MySQL server.

Opening a Connection for Multiple Hosts with Failover

Data used by applications can be stored on multiple MySQL servers to provide high availability. Connector/NET provides a simple way to specify multiple hosts in a connection string for cases in which multiple MySQL servers are configured for replication and you are not concerned about the precise server your application connects to in the set. For an example of how to configure multiple hosts with replication, see Using Replication & Load balancing.

Starting in Connector/NET 8.0.19, both classic MySQL protocol and X Protocol connections permit the use of multiple host names and multiple endpoints (a *`host:port`* pair) in a connection string or URI scheme. For example:

```
// classic protocol example
"server=10.10.10.10:3306,192.101.10.2:3305,localhost:3306;uid=test;password=xxxx"

// X Protocol example
mysqlx://test:test@[192.1.10.10:3305,127.0.0.1:3306]
```

An updated failover approach selects the target for connection first by priority order, if provided, or random order when no priority is specified. If the attempted connection to a selected target is unsuccessful, Connector/NET selects a new target from the list until no more hosts are available. If enabled, Connector/NET uses connection pooling to manage unsuccessful connections (see Section 4.2, “Managing a Connection Pool in Connector/NET”).

Opening a Connection Using a Single DNS Domain

When multiple MySQL instances provide the same service in your installation, you can apply DNS Service (SRV) records to provide failover, load balancing, and replication services. DNS SRV records remove the need for clients to identify each possible host in the connection string, or for connections to be handled by an additional software component. They can also be updated centrally by administrators when servers are added or removed from the configuration or when their host names are changed. DNS SRV records can be used in combination with connection pooling, in which case connections to hosts that are no longer in the current list of SRV records are removed from the pool when they become idle. For information about DNS SRV support in MySQL, see Connecting to the Server Using DNS SRV Records.

A service record is a specification of data managed by your domain name system that defines the location (host name and port number) of servers for the specified services. The record format defines the priority, weight, port, and target for the service as defined in the RFC 2782 specification (see https://tools.ietf.org/html/rfc2782). In the following SRV record example with four server targets (for `_mysql._tcp.foo.abc.com.`), Connector/NET uses the server selection order of `foo2`, `foo1`, `foo3`, and `foo4`.

```
Name                     TTL   Class   Priority Weight Port  Target
_mysql._tcp.foo.abc.com. 86400 IN SRV   0        5      3306  foo1.abc.com
_mysql._tcp.foo.abc.com. 86400 IN SRV   0        10     3306  foo2.abc.com
_mysql._tcp.foo.abc.com. 86400 IN SRV   10       5      3306  foo3.abc.com
```

```
_mysql._tcp.foo.abc.com. 86400 IN SRV   20       5      3306  foo4.abc.com
```

To open a connection using DNS SRV records, add the `dns-srv` connection option to your connection string. For example:

C# Example

```
var conn = new MySqlConnection("server=_mysql._tcp.foo.abc.com.;dns-srv=true;" +
            "user id=user;password=****;database=test");
```

For additional usage examples and restrictions for both classic MySQL protocol and X Protocol, see Options for Both Classic MySQL Protocol and X Protocol.

4.2 Managing a Connection Pool in Connector/NET

The MySQL Connector/NET supports connection pooling for better performance and scalability with database-intensive applications. This is enabled by default. You can turn it off or adjust its performance characteristics using the connection string options `Pooling`, `Connection Reset`, `Connection Lifetime`, `Cache Server Properties`, `Max Pool Size` and `Min Pool Size`. See Section 4.1, “Creating a Connector/NET Connection String” for further information.

Connection pooling works by keeping the native connection to the server live when the client disposes of a `MySqlConnection`. Subsequently, if a new `MySqlConnection` object is opened, it is created from the connection pool, rather than creating a new native connection. This improves performance.

Guidelines

To work as designed, it is best to let the connection pooling system manage all connections. Do not create a globally accessible instance of `MySqlConnection` and then manually open and close it. This interferes with the way the pooling works and can lead to unpredictable results or even exceptions.

One approach that simplifies things is to avoid creating a `MySqlConnection` object manually. Instead, use the overloaded methods that take a connection string as an argument. With this approach, Connector/NET automatically creates, opens, closes and destructs connections, using the connection pooling system for best performance.

Typed Datasets and the `MembershipProvider` and `RoleProvider` classes use this approach. Most classes that have methods that take a `MySqlConnection` as an argument, also have methods that take a connection string as an argument. This includes `MySqlDataAdapter`.

Instead of creating `MySqlCommand` objects manually, you can use the static methods of the `MySqlHelper` class. These methods take a connection string as an argument and they fully support connection pooling.

Resource Usage

Connector/NET runs a background job every three minutes and removes connections from pool that have been idle (unused) for more than three minutes. The pool cleanup frees resources on both client and server side. This is because on the client side every connection uses a socket, and on the server side every connection uses a socket and a thread.

Multiple endpoints. Starting with Connector/NET 8.0.19, a connection string can include multiple endpoints (*`server:port`*) with connection pooling enabled. At runtime, Connector/NET selects one of the addresses from the pool randomly (or by priority when provided) and attempts to connect to it. If the connection attempt is unsuccessful, Connector/NET selects another address until the set of addresses is exhausted. Unsuccessful endpoints are retried every two minutes. Successful connections are managed by the connection pooling mechanism.

4.3 Handling Connection Errors

Because connecting to an external server is unpredictable, it is important to add error handling to your .NET application. When there is an error connecting, the `MySqlConnection` class will return a `MySqlException` object. This object has two properties that are of interest when handling errors:

- `Message`: A message that describes the current exception.
- `Number`: The MySQL error number.

When handling errors, you can adapt the response of your application based on the error number. The two most common error numbers when connecting are as follows:

- `0`: Cannot connect to server.
- `1045`: Invalid user name, user password, or both.

The following code example shows how to manage the response of an application based on the actual error:

C# Example

```
MySql.Data.MySqlClient.MySqlConnection conn;
string myConnectionString;

myConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test";

try
{
    conn = new MySql.Data.MySqlClient.MySqlConnection(myConnectionString);
    conn.Open();
}
    catch (MySql.Data.MySqlClient.MySqlException ex)
{
    switch (ex.Number)
    {
        case 0:
            MessageBox.Show("Cannot connect to server.  Contact administrator");
            break;
        case 1045:
            MessageBox.Show("Invalid username/password, please try again");
            break;
    }
}
```

Visual Basic Example

```
Dim myConnectionString as String

myConnectionString = "server=127.0.0.1;" _
          & "uid=root;" _
          & "pwd=12345;" _
          & "database=test"

Try
    Dim conn As New MySql.Data.MySqlClient.MySqlConnection(myConnectionString)
    conn.Open()
Catch ex As MySql.Data.MySqlClient.MySqlException
    Select Case ex.Number
        Case 0
            MessageBox.Show("Cannot connect to server. Contact administrator")
```

```
        Case 1045
            MessageBox.Show("Invalid username/password, please try again")
    End Select
End Try
```

> **Important**
>
> If you are using multilanguage databases then you must specify the character set in the connection string. If you do not specify the character set, the connection defaults to the `latin1` character set. You can specify the character set as part of the connection string, for example:

```
MySqlConnection myConnection = new MySqlConnection("server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test;Charset=latin1");
```

4.4 Connector/NET Authentication

MySQL Connector/NET implements a variety of authentication plugins that MySQL Server can invoke to authenticate a user. Pluggable authentication enables the server to determine which plugin applies, based on the user name and host name that your application passes to the server when making a connection. For a complete description of the authentication process, see Pluggable Authentication.

Connector/NET provides the following authentication plugins and methods:

- authentication_fido_client
- authentication_kerberos_client
- authentication_ldap_sasl_client
- authentication_oci_client
- authentication_windows_client
- caching_sha2_password
- mysql_clear_password
- mysql_native_password
- sha256_password

authentication_fido_client

For general information, see FIDO Pluggable Authentication.

MySQL Enterprise Edition supports authentication to MySQL Server 8.0.27 (and higher) using devices such as smart cards, security keys, and biometric readers. This authentication method is based on the Fast Identity Online (FIDO) standard, and uses a pair of plugins, `authentication_fido` on the server side and `authentication_fido_client` on the client side. The client-side FIDO authentication plugin is supported by Connector/NET, starting with the 8.0.29 release.

The FIDO authentication method can be used directly for one-factor authentication (1FA) or combined with existing MySQL authentication methods to support accounts that use 2FA or 3FA. Connector/NET provides a callback mechanism to notify the application that the user is expected to interact with the authenticator. For example:

```
public void OpenConnection()
```

```
{
    using(var connection = new MySQLConnection("host=hostname; .. "))
      connection.FidoActionRequested += FidoActionRequested;
      connection.Open();
      // ...
}

public void FidoActionRequested()
{
    Console.WriteLine("Please insert FIDO device and perform gesture action for authentication to complete
}
```

If the following requirements are satisfied, Connector/NET notifies the application that it is expecting user interaction with the authenticator:

- The FIDO authenticator must be registered for the specific authentication factor associated with each user account.
- The application, Connector/NET, and the authenticator must be available on the same host or within a trusted network.
- On Windows, the application must run as administrator to access the required FIDO library, which must be present on the client.

The authentication process terminates after a reasonable time interval has elapsed without user-device interaction.

authentication_kerberos_client

For general information, see Kerberos Pluggable Authentication.

Applications and MySQL servers are able use the Kerberos authentication protocol to authenticate MySQL Enterprise Edition user accounts and services. With the `authentication_kerberos_client` plugin, both the user and the server are able to verify each other's identity. No passwords are ever sent over the network and Kerberos protocol messages are protected against eavesdropping and replay attacks. The server-side plugin is supported only on Linux.

> **Note**
>
> The `Defaultauthenticationplugin` connection-string option is mandatory for supporting userless and passwordless Kerberos authentications (see Options for Classic MySQL Protocol Only).

The availability of and the requirements for enabling Kerberos authentication differ by host type. Connector/NET does not provide Kerberos authentication for .NET applications running on macOS. On Windows, the Kerberos mode can be set using the `KerberosAuthMode` connection option (see Section 4.5, “Connector/NET Connection Options Reference”).

Applications running on Linux and Windows participate in Kerberos authentication based on the following interfaces:

- Generic Security Service Application Program Interface (GSSAPI)

  Minimum version:

  - Connector/NET 8.0.26 for classic MySQL protocol connections. Supported on Linux only.
  - Connector/NET 8.0.32 for classic MySQL protocol connections through the MIT Kerberos library. Supported on Windows only.

MIT Kerberos must be installed on each client system to enable authentication of request tickets for Connector/NET by a MySQL server. The `libgssapi_krb5.so.2` library for Linux is required. On Windows, use the `KRB5_CONFIG` and `KRB5CCNAME` environment variables to specify configuration and cache locations when using GSSAPI through the MIT Kerberos library.

For an overview of the connection process, see Connection Commands for Linux Clients.

- Security Support Provider Interface (SSPI) for Windows

  Minimum version: Connector/NET 8.0.27 for classic MySQL protocol connections. Supported on Windows only.

  Connector/NET uses SSPI/Kerberos for authentication. On Windows, SSPI implements GSSAPI. The behavioral differences between SSPI and GSSAPI include:

  - **Configuration.** Windows clients do not use any external libraries or Kerberos configuration. For example, with GSSAPI you can set the ticket-granting ticket (TGT) expiry time, key distribution center (KDC) port, and so on. With SSPI, you cannot set any of these options.
  - **TGT tickets caching.** If you provide a user name and password for authentication in `SSPI` mode, those credentials can be obtained from the Windows in-memory cache, but the obtained tickets are not stored in the Kerberos cache. New tickets are obtained every time.
  - **Userless and passwordless authentication.** In `SSPI` mode, Windows logged-in user name and credentials are used. Windows client must be part of the Active Directory domain of the server for a successful login.

  For an overview of the connection process, see Connection Commands for Windows Clients in SPPI Mode.

authentication_ldap_sasl_client

For general information, see LDAP Pluggable Authentication.

SASL-based LDAP authentication requires MySQL Enterprise Edition and can be used to establish classic MySQL protocol connections only. This authentication protocol applies to applications running on Linux, Windows (partial support), but not macOS.

Minimum version:

- Connector/NET 8.0.22 (`SCRAM-SHA-1`) on Linux and Windows.
- Connector/NET 8.0.23 (`SCRAM-SHA-256`) on Linux and Windows.
- Connector/NET 8.0.24 (`GSSAPI`) on Linux only.

  MIT Kerberos must be installed on each client system to enable authentication of request tickets for Connector/NET by a MySQL server. The `authentication_ldap_sasl` plugin must be configured to use the `GSSAPI` mechanism and the application user must be identified as follows:

  ```
  IDENTIFIED WITH 'authentication_ldap_sasl'
  ```

  The `libgssapi_krb5.so.2` library for Linux is required.

authentication_oci_client

Minimum version: Connector/NET 8.0.27 for classic MySQL protocol connections only.

Connector/NET supports Oracle Cloud Infrastructure pluggable authentication, which enables .NET applications to access MySQL HeatWave Service in a secure way without using passwords. This pluggable authentication is not supported for .NET Framework 4.5.*x* implementations.

Prerequisites for this type of connection include access to a tenancy, a Compute instance, a DB System attached to a private network, and properly configured groups, compartments, and policies. An Oracle Cloud Infrastructure administrator can provide the basic setup for MySQL user accounts.

In addition, the DB System must have the server-side authentication plugin installed and loaded before a connection can be attempted. Connector/NET implements the client-side authentication plugin.

During authentication, the client-side plugin locates the client user's Oracle Cloud Infrastructure configuration file from which it obtains a signing key file. The location of the configuration file can be specified with the `ociConfigFile` connection option; otherwise, the default location is used. In Connector/NET 8.0.33, the `OciConfigProfile` connection option permits selecting a profile in the configuration file to use for authentication. Connector/NET then signs a token it receives from the server, uses the token to create the SHA256 RSA signature that it returns to the server, and waits for the success or failure of the authentication process.

To support Oracle Cloud Infrastructure ephemeral key-based authentication, Connector/NET 8.0.33 (and later) obtains the location of the token file from the `security_token_file` entry. For example:

```
[DEFAULT]
fingerprint=59:8a:0b[...]
key_file=~/.oci/sessions/DEFAULT/oci_api_key.pem
tenancy=ocid1.tenancy.oc1.[...]
region=us-ashburn-1
security_token_file=~/.oci/sessions/DEFAULT/token
```

Connector/NET sends to the server a JSON attribute (named `"token"`) with the value extracted from the `security_token_file` field. If the target file referenced in the profile does not exist, or if the file exceeds a specified maximum value, then Connector/NET terminates the action and returns an exception with the cause.

Connector/NET sends an empty token value in the JSON payload if:

- The security-token file is empty.
- The configuration option `security_token_file` is found but the value in the configuration file is empty.

In all other cases, Connector/NET adds the content of the security-token file intact to the JSON document.

Potential error conditions include:

- `Private key could not be found at location given by OCI configuration entry 'key_file'.`

  Connector/NET could not find the private key at the specified location.

- `OCI configuration entry 'key_file' does not reference a valid key file.`

  Connector/NET was unable to load or use the specified private key.

- `OCI configuration file does not contain a 'fingerprint' or 'key_file' entry.`

  The configuration file is missing the `fingerprint` entry, the `key_file` entry, or both.

- `OCI configuration file could not be read`

Connector/NET could not find or load the configuration file. Be sure the `ociConfigFile` value matches the location of the file.

- `The OCI SDK cannot be found or is not installed`

  Connector/NET could not load the Oracle Cloud Infrastructure SDK library at run time.

Connector/NET references the `OCI.DotNetSDK.Common` NuGet package in the Oracle Cloud Infrastructure SDK library to read configuration-file entry values and this package must be available.

> **Tip**
>
> To manage the size of your .NET project, include only the required package for authentication rather than the full set of packages in the library.

For specific details about usage and support, see SDK and CLI Configuration File.

authentication_windows_client

Supported for all versions of Connector/NET. For general information, see Windows Pluggable Authentication.

MySQL Connector/NET applications can authenticate to a MySQL server using the Windows Native Authentication Plugin. Users who have logged in to Windows can connect from MySQL client programs to the server based on the information in their environment without specifying an additional password. The interface matches the MySql.Data.MySqlClient object. To enable, pass in `Integrated Security` to the connection string with a value of `yes` or `sspi`.

Passing in a user ID is optional. When Windows authentication is set up, a MySQL user is created and configured to be used by Windows authentication. By default, this user ID is named `auth_windows`, but can be defined using a different name. If the default name is used, then passing the user ID to the connection string from Connector/NET is optional, because it will use the `auth_windows` user. Otherwise, the name must be passed to the connection string using the standard user ID element.

caching_sha2_password

Minimum version: Connector/NET 8.0.11 for classic MySQL protocol connections only. For general information, see Caching SHA-2 Pluggable Authentication.

mysql_clear_password

Minimum version: Connector/NET 8.0.22 for classic MySQL protocol connections only. For general information, see Client-Side Cleartext Pluggable Authentication.

`mysql_clear_password` requires a secure connection to the server, which is satisfied by either condition at the client:

- The SslMode connection option has a value other than `Disabled` or `None` (deprecated in Connector/NET 8.0.29). The value is set to `Preferred` by default.
- The ConnectionProtocol connection option is set to `unix` for Unix domain sockets.

mysql_native_password

Supported for all versions of Connector/NET to establish classic MySQL protocol and X Protocol connections. For general information, see Native Pluggable Authentication.

sha256_password

Minimum version: Connector/NET 8.0.11 for classic MySQL protocol connections or X Protocol connections with the `MYSQL41` mechanism (see the Auth connection option). For general information, see SHA-256 Pluggable Authentication.

4.5 Connector/NET Connection Options Reference

This chapter describes the full set of MySQL Connector/NET 8.0 connection options. The protocol you use to make a connection to the server (classic MySQL protocol or X Protocol) determines which options you should use. Connection options have a default value that you can override by defining the new value in the connection string (classic MySQL protocol and X Protocol) or in the URI-like connection string (X Protocol). Connector/NET option names and synonyms are not case sensitive.

For instructions about how to use connection strings, see Section 4.1, “Creating a Connector/NET Connection String”. For alternative connection styles, see Connecting to the Server Using URI-Like Strings or Key-Value Pairs.

The following sections list the connection options that apply to both protocols, classic MySQL protocol only, and X Protocol only:

- Options for Both Classic MySQL Protocol and X Protocol
- Options for Classic MySQL Protocol Only
- Options for X Protocol Only

Options for Both Classic MySQL Protocol and X Protocol

The following Connector/NET connection options can be used with either protocol. Connector/NET 8.0 exposes the options in this section as properties in both the `MySql.Data.MySqlClient.MySqlConnectionStringBuilder` and `MySqlX.XDevAPI.MySqlXConnectionStringBuilder` classes.

`CertificateFile`, `Certificate File`

Default: `null`

This option specifies the path to a certificate file in PKCS #12 format (`.pfx`). For an example of usage, see Section 6.7.2, “Using PFX Certificates in Connector/NET”.

`CertificatePassword`, `Certificate Password`

Default: `null`

Specifies a password that is used in conjunction with a certificate specified using the option `CertificateFile`. For an example of usage, see Section 6.7.2, “Using PFX Certificates in Connector/NET”.

`CertificateStoreLocation`, `Certificate Store Location`

Default: `null`

Enables you to access a certificate held in a personal store, rather than use a certificate file and password combination. For an example of usage, see Section 6.7.2, “Using PFX Certificates in Connector/NET”.

`CertificateThumbprint`, `Certificate Thumbprint`

Default: `null`

Specifies a certificate thumbprint to ensure correct identification of a certificate contained within a personal store. For an example of usage, see Section 6.7.2, “Using PFX Certificates in Connector/NET”.

`CharacterSet`, `Character Set`, `CharSet`

Specifies the character set that should be used to encode all queries sent to the server. Results are still returned in the character set of the result data.

`ConnectionProtocol`, `Protocol`, `Connection Protocol`

Default: `socket` (or `tcp`)

Specifies the type of connection to make to the server. Values can be:

- `socket` or `tcp` for a socket connection using TCP/IP.
- `pipe` for a named pipe connection (not supported with X Protocol).
- `unix` for a UNIX socket connection.
- `memory` to use MySQL shared memory (not supported with X Protocol).

`Database`, `Initial Catalog`

Default: `mysql`

The case-sensitive name of the database to use initially.

`dns-srv`, `dnssrv`

Default: `false`

Enables the connection to resolve service (SRV) addresses in a DNS SRV record, which defines the location (host name and port number) of servers for the specified services when it is used with the default transport protocol (`tcp`). A single DNS domain can map to multiple targets (servers) using SRV address records. Each SRV record includes the host name, port, priority, and weight. DNS SRV support was introduced in Connector/NET 8.0.19 to remove the need for clients to identify each possible host in the connection string, with or without connection pooling.

Specifying multiple host names, a port number, or a Unix socket, named pipe, or shared memory connection (see the `ConnectionProtocol` option) in the connection string is not permitted when DNS SRV is enabled.

Using classic MySQL protocol. The `dns-srv` option applies to connection strings; the `DnsSrv` property is declared in the `MySqlConnectionStringBuilder` class.

```
// Connection string example

 var conn = new MySqlConnection("server=_mysql._tcp.example.abc.com.;
                                dns-srv=true;
                                user id=user;
                                password=****;
                                database=test");


// MySqlConnectionStringBuilder class example

 var sb = new MySqlConnectionStringBuilder();
{
  Server = "_mysql._tcp.example.abc.com.",
  UserID = "user",
  Password = "*****",
  DnsSrv = true,
  Database = "test"
```

```
};

var conn = new MySqlConnection(sb.ConnectionString);
```

Using X Protocol. The `dns-srv` option applies to connection strings and anonymous objects. The `DnsSrv` property is declared in the `MySqlXConnectionStringBuilder` class. An error is raised if both `dns-srv=false` and the URI scheme of `mysqlx+srv://` are combined to create a conflicting connection configuration. For details about using the `mysqlx+srv://` scheme element in URI-like connection strings, see Connections Using DNS SRV Records.

```
// Connection string example

var session = MySQLX.GetSession("server=_mysqlx._tcp.example.abc.com.;
                                dns-srv=true;
                                user id=user;
                                password=****;
                                database=test");


// Anonymous object example

var connstring = new
{
  server = "_mysqlx._tcp.example.abc.com.",
  user = "user",
  password = "****",
  dnssrv = true
};

var session = MySQLX.GetSession(connString);


// MySqlXConnectionStringBuilder class example

var sb = new MySqlXConnectionStringBuilder();
{
  Server = "_mysqlx._tcp.example.abc.com.",
  UserID = "user",
  Password = "****",
  DnsSrv = true,
  Database = "test"
};

var session = MySQLX.GetSession(sb.ConnectionString);
```

`Keepalive`, `Keep Alive`

Default: `0`

For TCP connections, idle connection time measured in seconds, before the first keepalive packet is sent. A value of 0 indicates that `keepalive` is not used. Before Connector/NET 6.6.7/6.7.5/6.8.4, this value was measured in milliseconds.

`Password`, `Password1`, `pwd`, `pwd1`

Default: an empty string

The password for the MySQL account being used for one-factor/single-factor authentication (1FA/SFA), which uses only one authentication method such as a password.

Starting with Connector/NET 8.0.28, this option also provides the first secret password for an account that has multiple authentication factors.

The server can require one (1FA), two (2FA), or three (3FA) passwords to authenticate the MySQL account. For example, if an account with 2FA is created as follows:

```
CREATE USER 'abe'@'localhost'
  IDENTIFIED WITH caching_sha2_password
    BY 'sha2_password'
  AND IDENTIFIED WITH authentication_ldap_sasl
    AS 'uid=u1_ldap,ou=People,dc=example,dc=com';
```

Then your application can specify a connection string with this option (`password` or its synonyms) and a value, *`sha2_password`* in this case, to satisfy the first authentication factor.

```
var connString =  "server=localhost;
                   user=abe;
                   password=sha2_password;
                   password2=ldap_password;
                   port=3306";
```

Alternatively, for a connection made using the `MySqlConnectionStringBuilder` object:

```
MySqlConnectionStringBuilder settings = new MySqlConnectionStringBuilder()
    {
      Server = "localhost",
      UserID = "abe",
      Pwd1 = "sha2_password",
      Pwd2 = "ldap_password",
      Port = 3306
    };
```

If the server does not require a secret password be used with an authentication method, then the value specified for the `password`, `password2`, or `password3` option is ignored.

`Password2` , `pwd2`

Default: an empty string

The second secret password for an account that has multiple authentication factors (see the `Password` connection option).

`Password3` , `pwd3`

Default: an empty string

The third secret password for an account that has multiple authentication factors (see the `Password` connection option).

`Port`

Default: `3306`

The port MySQL is using to listen for connections. This value is ignored if Unix socket is used.

`Server` , `Host` , `Data Source` , `DataSource`

Default: `localhost`

The name or network address of one or more host computers. Multiple hosts are separated by commas and a priority (0 to 100), if provided, determines the host selection order. As of Connector/NET 8.0.19, host selection is random when priorities are omitted or are the same for each host.

```
// Selects the host with the highest priority (100) first
server=(address=192.10.1.52:3305,priority=60),(address=localhost:3306,priority
```

	No attempt is made by the provider to synchronize writes to the database, so take care when using this option. In UNIX environments with Mono, this can be a fully qualified path to a MySQL socket file. With this configuration, the UNIX socket is used instead of the TCP/IP socket. Currently, only a single socket name can be given, so accessing MySQL in a replicated environment using UNIX sockets is not currently supported.
`SslCa` , `Ssl-Ca`	Default: `null` Based on the type of certificates being used, this option either specifies the path to a certificate file in PKCS #12 format (`.pfx`) or the path to a file in PEM format (`.pem`) that contains a list of trusted SSL certificate authorities (CA). With PFX certificates in use, this option engages when the `SslMode` connection option is set to a value of `Required`, `VerifyCA`, or `VerifyFull`; otherwise, it is ignored. With PEM certificates in use, this option engages when the `SslMode` connection option is set to a value of `VerifyCA` or `VerifyFull`; otherwise, it is ignored. For examples of usage, see Section 6.7.1, “Using PEM Certificates in Connector/NET”.
`SslCert` , `Ssl-Cert`	Default: `null` The name of the SSL certificate file in PEM format to use for establishing an encrypted connection. This option engages only when `VerifyFull` is set for the `SslMode` connection option and the `SslCa` connection option uses a PEM certificate; otherwise, it is ignored. For an example of usage, see Section 6.7.1, “Using PEM Certificates in Connector/NET”.
`SslKey` , `Ssl-Key`	Default: `null` The name of the SSL key file in PEM format to use for establishing an encrypted connection. This option engages only when `VerifyFull` is set for the `SslMode` connection option and the `SslCa` connection option uses a PEM certificate; otherwise, it is ignored. For an example of usage, see Section 6.7.1, “Using PEM Certificates in Connector/NET”.

`SslMode` , `Ssl Mode` , `Ssl-Mode`

Default: Depends on the version of Connector/NET and the protocol in use. Named-pipe and shared-memory connections are not supported with X Protocol.

- `Required` for 8.0.8 to 8.0.12 (both protocols); 8.0.13 and later (X Protocol only).
- `Preferred` for 8.0.13 and later (classic MySQL protocol only).

This option has the following values:

- `Disabled` – Do not use SSL. Non-SSL enabled servers require this option be set to `Disabled` explicitly for Connector/NET 8.0.29 or later.
- `None` – Do not use SSL. Non-SSL enabled servers require this option be set to `None` explicitly for Connector/NET 8.0.8 or later.

  Note

  This value is deprecated starting with Connector/NET 8.0.29. Use `Disabled` instead.

- `Preferred` – Use SSL if the server supports it, but allow connection in all cases. This option was removed in Connector/NET 8.0.8 and reimplemented in 8.0.13 for classic MySQL protocol only.

  Note

  Do not use this option for X Protocol operations.

- `Required` – Always use SSL. Deny connection if server does not support SSL.
- `VerifyCA` – Always use SSL. Validate the certificate authorities (CA), but tolerate a name mismatch.
- `VerifyFull` – Always use SSL. Fail if the host name is not correct.

`tlsversion` , `tls-version` , `tls version`

Default: A fallback solution decides which version of TLS to use.

Restricts the set of TLS protocol versions to use during the TLS handshake when both the client and server support the TLS versions indicated and the value of the `SslMode` connection-string option is not set to `Disabled` or `None` (deprecated in Connector/NET 8.0.29). This option accepts a single version or a list of versions separated by a comma, for example, `tls-version=TLSv1.2, TLSv1.3;`.

Connector/NET supports the following values:

- `TLSv1.3`

- `TLSv1.2`

An error is reported when a value other than those listed is assigned. Likewise, an error is reported when an empty list is provided as the value, or if all of the versions in the list are unsupported and no connection attempt is made.

`UserID`, `User Id`, `Username`, `Uid`, `User name`, `User`

Default: `null`

The MySQL login account being used.

Options for Classic MySQL Protocol Only

Options related to systems using a connection pool appear together at the end of the list of general options (see Connection-Pooling Options). Connector/NET 8.0 exposes the options in this section as properties in the `MySql.Data.MySqlClient.MySqlConnectionStringBuilder` class.

General Options. The Connector/NET options that follow are for general use with connection strings and the options apply to all MySQL server configurations:

`AllowBatch`, `Allow Batch`

Default: `true`

When `true`, multiple SQL statements can be sent with one command execution. Batch statements should be separated by the server-defined separator character.

`AllowLoadLocalInfile`, `Allow Load Local Infile`

Default: `false`

Disables (by default) or enables the server functionality to load the data local infile. If this option is set to `true`, uploading files from any location is enabled, regardless of the path specified with the `AllowLoadLocalInfileInPath` option.

`AllowLoadLocalInfileInPath`, `Allow Load Local Infile In Path`

Default: `null`

Specifies a safe path from where files can be read and uploaded to the server. When the related `AllowLoadLocalInfile` option is set to `false`, which is the default value, only those files from the safe path or any valid subfolder specified with the `AllowLoadLocalInfileInPath` option can be loaded. For example, if `/tmp` is set as the restricted folder, then file requests for `/tmp/myfile` and `/tmp/myfolder/myfile` can succeed. No relative paths or symlinks that fall outside of this path are permitted.

The following table shows the behavior that results when the `AllowLoadLocalInfile` and `AllowLoadLocalInfileInPath` connection string options are combined.

AllowLoadLocalInfile Value	AllowLoadLocalInfileInPath Value	Behavior
`true`	Empty string or `null` value	All uploads are permitted.
`true`	A valid path	All uploads are permitted

AllowLoadLocalInfile Value	AllowLoadLocalInfileDir Value	AllowLoadLocalInfileFilter Value
		(the path is not respected).
`false`	Empty string or `null` value	No uploads are permitted.
`false`	A valid path	Only uploads from the specified folder and subfolder are permitted.

`AllowPublicKeyRetrieval` Default: `false`

Setting this option to `true` informs Connector/NET that RSA public keys should be retrieved from the server and that connections using the classic MySQL protocol, when SSL is disabled, will fail by default. Exceptions to the default behavior can occur when previous successful connection attempts were made or when pooling is enabled and a pooled connection can be reused. This option was introduced with the 8.0.10 connector.

> **Caution**
>
> This option is prone to man-in-the-middle attacks, so it should be used only in situations where you can ensure by other means that your connections are made to trusted servers.

`AllowUserVariables` , `Allow User Variables` Default: `false`

Setting this to `true` indicates that the provider expects user variables in the SQL.

`AllowZeroDateTime` , `Allow Zero Datetime` Default: `false`

If set to `True`, `MySqlDataReader.GetValue()` returns a `MySqlDateTime` object for date or datetime columns that have disallowed values, such as zero datetime values, and a `System.DateTime` object for valid values. If set to `False` (the default setting) it causes a `System.DateTime` object to be returned for all valid values and an exception to be thrown for disallowed values, such as zero datetime values.

`AutoEnlist` , `Auto Enlist` Default: `true`

If `AutoEnlist` is set to `true`, which is the default, a connection opened using `TransactionScope` participates in this scope, it commits when the scope commits and rolls back if `TransactionScope` does not commit. However, this feature is considered security sensitive and therefore cannot be used in a medium trust environment.

As of 8.0.10, this option is supported in .NET Core 2.0 implementations.

`BlobAsUTF8ExcludePattern` Default: `null`

A POSIX-style regular expression that matches the names of BLOB columns that do not contain UTF-8 character data. See Section 5.16, “Character Set Considerations for Connector/NET” for usage details.

`BlobAsUTF8IncludePattern` Default: `null`

A POSIX-style regular expression that matches the names of BLOB columns containing UTF-8 character data. See Section 5.16, “Character Set Considerations for Connector/NET” for usage details.

`CheckParameters`, `Check Parameters` Default: `true`

Indicates if stored routine parameters should be checked against the server.

`CommandInterceptors`, `Command Interceptors` The list of interceptors that can intercept SQL command operations.

`ConnectionTimeout`, `Connect Timeout`, `Connection Timeout` Default: `15`

The length of time (in seconds) to wait for a connection to the server before terminating the attempt and generating an error.

`ConvertZeroDateTime`, `Convert Zero Datetime` Default: `false`

Use `true` to have `MySqlDataReader.GetValue()` and `MySqlDataReader.GetDateTime()` return `DateTime.MinValue` for date or datetime columns that have disallowed values.

`DefaultAuthenticationPlugin` Takes precedence over the server-side default authentication plugin when a valid authentication plugin is specified (see Section 4.4, “Connector/NET Authentication”). The `Defaultauthenticationplugin` option is mandatory for supporting userless and passwordless Kerberos authentications in which the credentials are retrieved from a cache or the Key Distribution Center (KDC). For example:

```
MySqlConnectionStringBuilder settings = new MySqlConnectionStringBuilder()
    {
      Server = "localhost",
      UserID = "",
      Password = "",
      Database = "mydb",
      Port = 3306,
      DefaultAuthenticationPlugin = "authentication_kerberos_client"
    };
```

If no value is set, the server-side default authentication plugin is used.

This option was introduced with the 8.0.26 connector.

`DefaultCommandTimeout`, `Default Command Timeout` Default: `30`

Sets the default value of the command timeout to be used. This does not supersede the individual command timeout property on an individual command object. If you set the command timeout property, that will be used.

`DefaultTableCacheAge`, `Default Table Cache Age`

Default: `60`

Specifies how long a `TableDirect` result should be cached, in seconds. For usage information about table caching, see Section 5.3, “Using Connector/NET with Table Caching”.

`ExceptionInterceptors`, `Exception Interceptors`

The list of interceptors that can triage thrown `MySqlException` exceptions.

`FunctionsReturnString`, `Functions Return String`

Default: `false`

Causes the connector to return `binary` or `varbinary` values as strings, if they do not have a table name in the metadata.

`Includesecurityasserts`, `Include security asserts`

Default: `false`

Must be set to `true` when using the `MySQLClientPermissions` class in a partial trust environment, with the library installed in the GAC of the hosting environment. See Section 5.7, “Working with Partial Trust / Medium Trust” for details.

As of 8.0.10, this option is supported in .NET Core 2.0 implementations.

`InteractiveSession`, `Interactive`, `Interactive Session`

Default: `false`

If set to `true`, the client is interactive. An interactive client is one in which the server variable `CLIENT_INTERACTIVE` is set. If an interactive client is set, the `wait_timeout` variable is set to the value of `interactive_timeout`. The client session then times out after this period of inactivity. For more information, see Server System Variables in the MySQL Reference Manual.

As of 8.0.10, this option is supported in .NET Core 2.0 implementations.

`IntegratedSecurity`, `Integrated Security`

Default: `no`

Use Windows authentication when connecting to server. By default, it is turned off. To enable, specify a value of `yes`. (You can also use the value `sspi` as an alternative to `yes`.) For details, see Section 4.4, “Connector/NET Authentication”.

Currently not supported for .NET Core implementations.

`KerberosAuthMode`, `kerberos auth mode`

Default: `AUTO`

On Windows, provides authentication support using Security Support Provider Interface (SSPI), which is capable of acquiring credentials from the Windows in-memory cache, and Generic Security Service Application Program Interface (GSSAPI) through the MIT Kerberos library. GSSAPI is capable of acquiring cached credentials previously generated using the `kinit` command. The default value for this option

(AUTO) attempts to authenticate with GSSAPI if the authentication using SSPI fails.

> **Note**
>
> This option is permitted in Windows environments only. Using it in non-Windows environments produces an *Option not supported* exception.

Possible values for this connection option are:

- AUTO – Use SSPI and fall back to GSSAPI in case of failure.
- SSPI – Use SSPI only and raise an exception in case of failure.
- GSSAPI – Use GSSAPI only and raise an exception in case of failure. Always use the KRB5_CONFIG and KRB5CCNAME environment variables to specify configuration and cache locations when using GSSAPI through the MIT Kerberos library on Windows.

Logging

Default: false

When the value is set to true, various pieces of information are sent to all configured trace listeners. For a more detailed description, see Section 5.12, “Connector/NET Tracing”.

As of 8.0.10, this option is supported in .NET Core 2.0 implementations.

ociConfigFile , OCI Config File

Defaults to one of the following path names:

- ~/.oci/config on Linux and macOS host types
- %HOMEDRIVE%%HOMEPATH%\.oci\config on Windows host types

If set, this option specifies an alternative location to the Oracle Cloud Infrastructure configuration file. Connector/NET 8.0.27 (and later) uses the Oracle Cloud Infrastructure SDK to obtain a fingerprint of the API key to use for authentication (fingerprint entry) and location of a PEM file with the private part of the API key (key_file entry). The entries should be specified in the [DEFAULT] profile. If the [DEFAULT] profile is missing from the configuration file, Connector/NET locates the next profile to use instead.

Not supported for .NET Framework 4.5.x implementations.

OciConfigProfile , OCI Config Profile

If set in Connector/NET 8.0.33 (or later), this option specifies which profile in an Oracle Cloud Infrastructure configuration file to use. The profile value defaults to the DEFAULT profile when no value is provided.

Not supported for .NET Framework 4.5.x implementations.

OldGuids , Old Guids

Default: false

The back-end representation of a GUID type was changed from BINARY(16) to CHAR(36). This was done to allow developers to use the server function UUID() to populate a GUID table - UUID()

generates a 36-character string. Developers of older applications can add `'Old Guids=true'` to the connection string to use a GUID of data type `BINARY(16)`.

`PersistSecurityInfo`, `Persist Security Info`

Default: `false`

When set to `false` or `no` (strongly recommended), security-sensitive information, such as the password, is not returned as part of the connection if the connection is open or has ever been in an open state. Resetting the connection string resets all connection string values, including the password. Recognized values are `true`, `false`, `yes`, and `no`.

`PipeName`, `Pipe Name`, `Pipe`

Default: `mysql`

When set to the name of a named pipe, the `MySqlConnection` attempts to connect to MySQL on that named pipe. This setting only applies to the Windows platform.

> **Important**
>
> For MySQL 8.0.14 and later, 5.7.25 and later, and 5.6.43 and later, minimal permissions on named pipes are granted to clients that use them to connect to the server. However, Connector/NET can use named pipes only when granted full access on them. As a workaround, create a Windows local group containing the user that executes the client application. Restart the target server with the `named_pipe_full_access_group` system variable and specify the local group name as its value.

Currently not supported for .NET Core implementations.

`ProcedureCacheSize`, `Procedure Cache Size`, `procedure cache`, `procedurecache`

Default: `25`

Sets the size of the stored procedure cache. By default, Connector/NET stores the metadata (input/output data types) about the last 25 stored procedures used. To disable the stored procedure cache, set the value to zero (0).

`Replication`

Default: `false`

Indicates if this connection is to use replicated servers.

As of 8.0.10, this option is supported in .NET Core 2.0 implementations.

`RespectBinaryFlags`, `Respect Binary Flags`

Default: `true`

Setting this option to `false` means that Connector/NET ignores a column's binary flags as set by the server.

`SharedMemoryName`, `Shared Memory Name`

Default: `mysql`

The name of the shared memory object to use for communication if the transport protocol is set to `memory`. This setting only applies to the Windows platform.

Currently not supported for .NET Core implementations.

`SqlServerMode`, `Sql Server Mode`

Default: `false`

Allow SQL Server syntax. When set to `true`, enables Connector/NET to support square brackets around symbols instead of backticks. This enables Visual Studio wizards that bracket symbols between the `[` and `]` characters to work with Connector/NET. This option incurs a performance hit, so should only be used if necessary.

`TableCaching`, `Table Cache`, `TableCache`

Default: `false`

Enables or disables caching of `TableDirect` commands. A value of `true` enables the cache while `false` disables it. For usage information about table caching, see Section 5.3, “Using Connector/NET with Table Caching”.

`TreatBlobsAsUTF8`, `Treat BLOBs as UTF8`

Default: `false`

Setting this value to `true` causes `BLOB` columns to have a character set of `utf8` with the default collation for that character set. To convert only some of your BLOB columns, you can make use of the `'BlobAsUTF8IncludePattern'` and `'BlobAsUTF8ExcludePattern'` keywords. Set these to a regular expression pattern that matches the column names to include or exclude respectively.

`TreatTinyAsBoolean`, `Treat Tiny As Boolean`

Default: `true`

Setting this value to `false` causes `TINYINT(1)` to be treated as an `INT`. See Numeric Data Type Syntax for a further explanation of the `TINYINT` and `BOOL` data types.

`UseAffectedRows`, `Use Affected Rows`

Default: `false`

When `true`, the connection reports changed rows instead of found rows.

`UseCompression`, `Compress`, `Use Compression`

Default: `false`

Setting this option to `true` enables compression of packets exchanged between the client and the server. This exchange is defined by the MySQL client/server protocol.

Compression is used if both client and server support ZLIB compression, and the client has requested compression using this option.

A compressed packet header is: packet length (3 bytes), packet number (1 byte), and Uncompressed Packet Length (3 bytes). The Uncompressed Packet Length is the number of bytes in the original,

	uncompressed packet. If this is zero, the data in this packet has not been compressed. When the compression protocol is in use, either the client or the server may compress packets. However, compression will not occur if the compressed length is greater than the original length. Thus, some packets will contain compressed data while other packets will not.
`UseDefaultCommandTimeoutForEF`, `Use Default Command Timeout For EF`	Default: `false` Enforces the command timeout of `EFMySqlCommand`, which is set to the value provided by the `DefaultCommandTimeout` property.
`UsePerformanceMonitor`, `Use Performance Monitor`, `UserPerfMon`, `PerfMon`	Default: `false` Indicates that performance counters should be updated during execution. *Currently not supported for .NET Core implementations.*
`UseUsageAdvisor`, `Use Usage Advisor`, `Usage Advisor`	Default: `false` Logs inefficient database operations. As of 8.0.10, this option is supported in .NET Core 2.0 implementations.

Connection-Pooling Options. The following options are related to connection pooling within connection strings. For more information about connection pooling, see Opening a Connection to a Single Server.

`CacheServerProperties`, `Cache Server Properties`	Default: `false` Specifies whether server variable settings are updated by a `SHOW VARIABLES` command each time a pooled connection is returned. Enabling this setting speeds up connections in a connection pool environment. Your application is not informed of any changes to configuration variables made by other connections.
`ConnectionLifeTime`, `Connection Lifetime`	Default: `0` When a connection is returned to the pool, its creation time is compared with the current time and the connection is destroyed if that time span (in seconds) exceeds the value specified by `Connection Lifetime`. This option is useful in clustered configurations to force load balancing between a running server and a server just brought online. A value of zero (0) sets pooled connections to the maximum connection timeout.
`ConnectionReset`, `Connection Reset`	Default: `false` If `true`, the connection state is reset when it is retrieved from the pool. The default value of false avoids making an additional server round trip when obtaining a connection, but the connection state is not reset.
`MaximumPoolsize`, `Max Pool Size`, `Maximum Pool Size`, `MaxPoolSize`	Default: `100` The maximum number of connections allowed in the pool.

`MinimumPoolSize`, `Min Pool Size`, `Minimum Pool Size`, `MinPoolSize`

Default: `0`

The minimum number of connections allowed in the pool.

`Pooling`

Default: `true`

When `true`, the `MySqlConnection` object is drawn from the appropriate pool, or if necessary, is created and added to the appropriate pool. Recognized values are `true`, `false`, `yes`, and `no`.

Options for X Protocol Only

The connection options that follow are valid for connections made with X Protocol. Connector/NET 8.0 exposes the options in this section as properties in the `MySqlX.XDevAPI.MySqlXConnectionStringBuilder` class.

`Auth`, `Authentication`, `Authentication Mode`

Authentication mechanism to use with the X Protocol. This option was introduced with the 8.0.9 connector and has the following values, which are not case-sensitive: `MYSQL41`, `PLAIN`, and `EXTERNAL`. If the `Auth` option is not set, the mechanism is chosen depending on the connection type. `PLAIN` is used for secure connections (TLS or Unix sockets) and `MYSQL41` is used for unencrypted connections. `EXTERNAL` is used for external authentication methods such as PAM, Windows login IDs, LDAP, or Kerberos. (`EXTERNAL` is not currently supported.)

The `Auth` option is not supported for classic MySQL protocol connections and returns `NotSupportedException` if used.

`Compression`, `use-compression`

Default: `preferred`

Compression is used to send and receive data when both the client and server support it for X Protocol connections and the client requests compression using this option. After a successful algorithm negotiation is made, Connector/NET can start compressing data immediately. To prevent the compression of small data packets, or of data already compressed, Connector/NET defines a size threshold of 1000 bytes.

When multiple compression algorithms are supported by the server, Connector/NET applies the following priority by default: `zstd_stream` (first), `lz4_message` (second), and `deflate_stream` (third). The `deflate_stream` algorithm is supported for use with .NET Core, but not for .NET Framework.

> **Tip**
>
> Use the `compression-algorithms` option to specify one ore more supported algorithms in a different order. The algorithms are negotiated in the order provided by client. For usage details, see the `compression-algorithms` option.

Data compression for X Protocol connections was added in the Connector/NET 8.0.20 release. The `Compression` option accepts the following values:

- `preferred` to apply data compression if the server supports the algorithms chosen by the client. Otherwise, the data is sent and received without compression.
- `required` to ensure that compression is used or to terminate the connection and return an error message.
- `disabled` to prevent data compression.

`compression-algorithms`, `CompressionAlgorithms`

As of Connector/NET 8.0.22, a client application can specify the order in which supported compression algorithms are negotiated with the server. The value of the `Compression` connection option must be set to `preferred` or to `required` for this option to apply. Unsupported algorithms are ignored.

This option accepts the following algorithm names and synonyms:

- `lz4_message` or `lz4`
- `zstd_stream` or `zstd`
- `deflate_stream` or `deflate` (not valid with .NET Framework)

Algorithm names and synonyms can be combined in a comma-separated list or provided as a standalone value (with or without brackets). Examples:

```
// Compression option set to preferred (default)
MySQLX.GetSession("mysqlx://test:test@localhost:3306?compression-algorithms=[l
MySQLX.GetSession("mysqlx://test:test@localhost:3306?compressionalgorithms=lz4
MySQLX.GetSession("mysqlx://test:test@localhost:3306?compression=preferred&com

// Compression option set to required
MySQLX.GetSession("mysqlx://test:test@localhost:3306?compression=required&comp
MySQLX.GetSession("mysqlx://test:test@localhost:3306?compression=required&comp
MySQLX.GetSession("mysqlx://test:test@localhost:3306?compression=required&comp

// Connection string
MySQLX.GetSession("server=localhost;port=3306;uid=test;password=test;compressi

// Anonymous object
MySQLX.GetSession(new {
   server = "localhost",
   port = "3306",
   uid = "test",
   password = "test",
   compression="required",
   compressionalgorithms = "deflate_stream" })
```

For additional information, see Connection Compression with X Plugin.

`connection-attributes`, `ConnectionAttributes`

Default: `true`

This option was introduced in Connector/NET 8.0.16 for submitting a set of attributes to be passed together with default connection attributes to the server. The aggregate size of connection attribute data sent by a client is limited by the value of the `performance_schema_session_connect_attrs_size` server variable. The total size of the data package should be less than the

value of the server variable. For general information about connection attributes, see Performance Schema Connection Attribute Tables.

The connection-attributes parameter value can be empty (the same as specifying `true`), a Boolean value (`true` or `false` to enable or disable the default attribute set), or a list or zero or more `key=value` specifiers separated by commas (to be sent in addition to the default attribute set). Within a list, a missing key value evaluates as the `NULL` value. Examples:

```
// Sessions
MySQLX.GetSession($"mysqlx://user@host/schema")
MySQLX.GetSession($"mysqlx://user@host/schema?connection-attributes")
MySQLX.GetSession($"mysqlx://user@host/schema?connection-attributes=true")
MySQLX.GetSession($"mysqlx://user@host/schema?connection-attributes=false"
MySQLX.GetSession($"mysqlx://user@host/schema?connection-attributes=[attr1
MySQLX.GetSession($"mysqlx://user@host/schema?connection-attributes=[]")

// Pooling
MySQLX.GetClient($"mysqlx://user@host/schema")
MySQLX.GetClient($"mysqlx://user@host/schema?connection-attributes")
MySQLX.GetClient($"mysqlx://user@host/schema?connection-attributes=true")
MySQLX.GetClient($"mysqlx://user@host/schema?connection-attributes=false")
MySQLX.GetClient($"mysqlx://user@host/schema?connection-attributes=[attr1=
MySQLX.GetClient($"mysqlx://user@host/schema?connection-attributes=[]")
```

Application-defined attribute names cannot begin with `_` because such names are reserved for internal attributes.

If connection attributes are not specified in a valid way, an error occurs and the connection attempt fails.

`Connect-Timeout` , `ConnectTimeout`

Default: `10000`

The length of time (in milliseconds) to wait for an X Protocol connection to the server before terminating the attempt and generating an error. You can disable the connection timeout by setting the value to zero. This option can be specified as follows:

- URI-like connection string example

```
MySQLX.GetSession("mysqlx://test:test@localhost:33060?connect-timeout=20
```

- Connection string example

```
MySQLX.GetSession("server=localhost;user=test;port=33060;connect-timeout
```

- Anonymous object example

```
MySQLX.GetSession(new { server="localhost", user="test", port=33060, con
```

- `MySqlXConnectionStringBuilder` class example

```
var builder = new MySqlXConnectionStringBuilder("server=localhost;user=t
builder.ConnectTimeout = 2000;
MySQLX.GetSession(builder.ConnectionString);
```

`SslCrl` , `Ssl-Crl`

Default: `null`

Path to a local file containing certificate revocation lists.

> **Important**
>
> Although the `SslCrl` connection-string option is valid for use, applying it raises a `NotSupportedException` message.

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MySQL Connector/NET comprises several classes that are used to connect to the database, execute queries and statements, and manage query results.

The following are the major classes of Connector/NET:

- `MySqlConnection`: Represents an open connection to a MySQL database (see Chapter 4, *Connector/NET Connections*).

  The `MySqlConnectionStringBuilder` class aids in the creation of a connection string by exposing the connection options as properties.

- `MySqlCommand`: Represents an SQL statement to execute against a MySQL database.

- `MySqlCommandBuilder`: Automatically generates single-table commands used to reconcile changes made to a DataSet with the associated MySQL database.

- `MySqlDataAdapter`: Represents a set of data commands and a database connection that are used to fill a data set and update a MySQL database.
- `MySqlDataReader`: Provides a means of reading a forward-only stream of rows from a MySQL database.
- `MySqlException`: The exception that is thrown when MySQL returns an error.
- `MySqlHelper`: Helper class that makes it easier to work with the provider.
- `MySqlTransaction`: Represents an SQL transaction to be made in a MySQL database.

5.1 Using GetSchema on a Connection

The `GetSchema()` method of the connection object can be used to retrieve schema information about the database currently connected to. The schema information is returned in the form of a `DataTable`. The schema information is organized into a number of collections. Different forms of the `GetSchema()` method can be used depending on the information required. There are three forms of the `GetSchema()` method:

- `GetSchema()` - This call will return a list of available collections.
- `GetSchema(String)` - This call returns information about the collection named in the string parameter. If the string “MetaDataCollections” is used then a list of all available collections is returned. This is the same as calling `GetSchema()` without any parameters.
- `GetSchema(String, String[])` - In this call the first string parameter represents the collection name, and the second parameter represents a string array of restriction values. Restriction values limit the amount of data that will be returned. Restriction values are explained in more detail in the Microsoft .NET documentation.

Collections

The collections can be broadly grouped into two types: collections that are common to all data providers, and collections specific to a particular provider.

Common Collections. The following collections are common to all data providers:

- MetaDataCollections
- DataSourceInformation
- DataTypes
- Restrictions
- ReservedWords

Provider-Specific Collections. The following are the collections currently provided by Connector/NET, in addition to the common collections shown previously:

- Databases
- Tables
- Columns
- Users
- Foreign Keys

- IndexColumns
- Indexes
- Foreign Key Columns
- UDF
- Views
- ViewColumns
- Procedure Parameters
- Procedures
- Triggers

C# Code Example. A list of available collections can be obtained using the following code:

```
using System;
using System.Data;
using System.Text;
using MySql.Data;
using MySql.Data.MySqlClient;

namespace ConsoleApplication2
{
    class Program
    {

        private static void DisplayData(System.Data.DataTable table)
        {
            foreach (System.Data.DataRow row in table.Rows)
            {
                foreach (System.Data.DataColumn col in table.Columns)
                {
                    Console.WriteLine("{0} = {1}", col.ColumnName, row[col]);
                }
                Console.WriteLine("============================");
            }
        }

        static void Main(string[] args)
        {

            string connStr = "server=localhost;user=root;database=world;port=3306;password=******";
            MySqlConnection conn = new MySqlConnection(connStr);

            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();

                DataTable table = conn.GetSchema("MetaDataCollections");
                //DataTable table = conn.GetSchema("UDF");
                DisplayData(table);

                conn.Close();
            }
            catch (Exception ex)
            {
                Console.WriteLine(ex.ToString());
            }
            Console.WriteLine("Done.");
        }
```

```
    }
}
```

Further information on the `GetSchema()` method and schema collections can be found in the Microsoft .NET documentation.

5.2 Using MySqlCommand

The MySqlCommand class represents a SQL statement to execute against a MySQL database. Class methods enable you to perform the following database operations:

- Query a database
- Insert, update, and delete data
- Return a single value

Command-based database operations can run within a transaction, if needed. For a short tutorial demonstrating how and when to use the `ExecuteReader`, `ExecuteNonQuery`, and `ExecuteScalar` methods, see Section 6.1.2, “The MySqlCommand Object”.

An instance of `MySqlCommand` can be organized to execute as a prepared statement for faster excecution and reuse, or as a stored procedure. A flexible set of class properties permits you to package MySQL commands in several forms. The remainder of this section describes following `MySqlCommand` properties:

- CommandText and CommandType Properties
- Parameters Property
- Attributes Property
- CommandTimeout Property

CommandText and CommandType Properties

The `MySqlCommand` class provides the `CommandText` and `CommandType` properties that you may combine to create the type of SQL statements needed for your project. The `CommandText` property is interpreted differently, depending on how you set the `CommandType` property. The following `CommandType` types are permitted:

- `Text` - An SQL text command (default).
- `StoredProcedure` - Name of a stored procedure.
- `TableDirect` - Name of a table.

The default `CommandType` type, `Text`, is used for executing queries and other SQL commands. See Section 6.1.2, “The MySqlCommand Object” for usage examples.

If `CommandType` is set to `StoredProcedure`, set `CommandText` to the name of the stored procedure to access. For use-case examples of the `CommandType` property with type `StoredProcedure`, see Section 5.5, “Creating and Calling Stored Procedures”.

If `CommandType` is set to `TableDirect`, all rows and columns of the named table are returned when you call one of the execute methods. In effect, this command performs a `SELECT *` on the table specified. The `CommandText` property is set to the name of the table to query. This usage is illustrated by the following code snippet:

```
...
```

```
MySqlCommand cmd = new MySqlCommand();
cmd.CommandText = "mytable";
cmd.Connection = someConnection;
cmd.CommandType = CommandType.TableDirect;
MySqlDataReader reader = cmd.ExecuteReader();
while (reader.Read())
{
   Console.WriteLn(reader[0], reader[1]...);
}
...
```

Parameters Property

The `Parameters` property gives you control over the data you use to build a SQL query. Defining a parameter is the preferred practice to reduce the risk of acquiring unwanted or malicous input. For usage information and examples, see:

- Working with Parameters
- Accessing a Stored Procedure
- Preparing Statements in Connector/NET

Attributes Property

As of Connector/NET 8.0.26, an instance of `MySqlCommand` can be organized to execute simple Transact-SQL statements or stored procedures, both can be used in a prepared statement for faster execution and reuse. The `query_attributes` component must be installed on the server (see Prerequisites for Using Query Attributes) before attributes can be searched for and used on the server side.

Query-attributes support varies by server version:

- Prior to MySQL Server 8.0.23: no support for query attributes.
- MySQL Server 8.0.23 to 8.0.24: support for query attributes in regular statements only.
- MySQL Server 8.0.25 and higher: support for query attributes in both regular and prepared statements.

If you send query attribute metadata to a server that does not support query attributes, the attempt is logged by the connector but no error is emitted.

Like parameters, attributes must be named. Unlike a parameter, an attribute represents an object from the underlying query, such as a field or table. Connector/NET does not check or enforce whether your attribute names are unique. Parameters and attributes can be combined together in commands without restrictions.

You can declare an attritue name and value directly by using the `SetAttribute` method to create an instance of `MySqlAttribute` that is exposed in a collection through the `MySqlAttributeCollection` object within `MySqlCommand`. For example, to declare a single attribute named `qa1`, use the following C# syntax:

```
myCommand.Attributes.SetAttribute("qa1", "qaValue");
```

Alternatively, you can declare a variable of type `MySqlAttribute` to hold your attribute name and value. Both forms persist the attribute after the query is executed, until the `Clear` method is called on the `MySqlAttributeCollection` object. The next snippet declares two attributes named `qa1` and `qa2` as variables `mySqlAttribute1` and `mySqlAttribute2`.

```
MySqlCommand myCommand = new MySqlCommand();
myCommand.Connection = myConnection;
```

```
MySqlAttribute mySqlAttribute1 = new MySqlAttribute("qa1", "qaValue");
MySqlAttribute mySqlAttribute2 = new MySqlAttribute("qa2", 2);

myCommand.Attributes.SetAttribute(mySqlAttribute1);
myCommand.Attributes.SetAttribute(mySqlAttribute2);
```

With attribute names and values defined, a statement specifying attributes can be sent to the server. The following `SELECT` statement includes the `mysql_query_attribute_string()` loadable function that is used to retrieve the two attributes decared previously and then prints the results. For more readable and convenient syntax, the `$` symbol is used in this example to identify string literals as interpolated strings.

```
myCommand.CommandText = $"SELECT mysql_query_attribute_string('{mySqlAttribute1.AttributeName}') AS attr1," +
  $"mysql_query_attribute_string('{mySqlAttribute2.AttributeName}') AS attr2";

using (var reader = myCommand.ExecuteReader())
{
  while (reader.Read())
  {
    Console.WriteLine($"Attribute1 Value: {reader.GetString(0)}");
    Console.WriteLine($"Attribute2 Value: {reader.GetString(1)}");
  }
}

/* Output:
 Attribute1 Value: qaValue
 Attribute2 Value: 2
*/
```

The following code block shows the same process for setting attributes and retrieving the results using Visual Basic syntax.

```
Public Sub CreateMySqlCommandWithQueryAttributes(ByVal myConnection As MySqlConnection)
  Dim myCommand As MySqlCommand = New MySqlCommand()
  myCommand.Connection = myConnection
  Dim mySqlAttribute1 As MySqlAttribute = New MySqlAttribute("qa1", "qaValue")
  Dim mySqlAttribute2 As MySqlAttribute = New MySqlAttribute("qa2", 2)
  myCommand.Attributes.SetAttribute(mySqlAttribute1)
  myCommand.Attributes.SetAttribute(mySqlAttribute2)
  myCommand.CommandText = $"SELECT mysql_query_attribute_string('{mySqlAttribute1.AttributeName}') AS attr1,"
    $"mysql_query_attribute_string('{mySqlAttribute2.AttributeName}') AS attr2"

  Using reader = myCommand.ExecuteReader()
    While reader.Read()
      Console.WriteLine($"Attribute1 Value: {reader.GetString(0)}")
      Console.WriteLine($"Attribute2 Value: {reader.GetString(1)}")
    End While
  End Using
End Sub
```

CommandTimeout Property

Commands can have a timeout associated with them. This feature is useful as you may not want a situation were a command takes up an excessive amount of time. A timeout can be set using the `CommandTimeout` property. The following code snippet sets a timeout of one minute:

```
MySqlCommand cmd = new MySqlCommand();
cmd.CommandTimeout = 60;
```

The default value is 30 seconds. Avoid a value of 0, which indicates an indefinite wait. To change the default command timeout, use the connection string option `Default Command Timeout`.

Connector/NET supports timeouts that are aligned with how Microsoft handles `SqlCommand.CommandTimeout`. This property is the cumulative timeout for all network reads and writes during command execution or processing of the results. A timeout can still occur in the

`MySqlReader.Read` method after the first row is returned, and does not include user processing time, only IO operations.

Further details on this can be found in the relevant Microsoft documentation.

5.3 Using Connector/NET with Table Caching

Table caching is a feature that can be used to cache slow-changing datasets on the client side. This is useful for applications that are designed to use readers, but still want to minimize trips to the server for slow-changing tables.

This feature is transparent to the application, and is disabled by default.

Configuration

- To enable table caching, add `'table cache = true'` to the connection string.
- Optionally, specify the `'Default Table Cache Age'` connection string option, which represents the number of seconds a table is cached before the cached data is discarded. The default value is `60`.
- You can turn caching on and off and set caching options at runtime, on a per-command basis.

5.4 Preparing Statements in Connector/NET

Prepared statements can provide significant performance improvements on queries that are executed more than one time. Prepared execution is faster than direct execution for statements executed more than once, primarily because the query is parsed only one time. In the case of direct execution, the query is parsed every time it is executed. In addition, prepared execution can provide a reduction of network traffic because for each execution of the prepared statement, it is necessary only to send the data for the parameters.

Another advantage of prepared statements is that, with server-side prepared statements enabled, it uses a binary protocol that makes data transfer between client and server more efficient.

To prepare a statement, use the following sequence of steps:

1. Create a `MySqlCommand` object and set the `CommandText` property to your query.
2. After entering your statement, call the `Prepare` method of the command object. When the statement is prepared, add parameters for each of the dynamic elements in the query.
3. Execute the statement using the `ExecuteNonQuery()`, `ExecuteScalar()`, or `ExecuteReader` methods.

For subsequent executions, you need only modify the values of the parameters and call the execute method again, there is no need to set the `CommandText` property or redefine the parameters.

C# Code Example

```
MySql.Data.MySqlClient.MySqlConnection conn;
MySql.Data.MySqlClient.MySqlCommand cmd;

conn = new MySql.Data.MySqlClient.MySqlConnection();
cmd = new MySql.Data.MySqlClient.MySqlCommand();

conn.ConnectionString = strConnection;

try
{
```

```
    conn.Open();
    cmd.Connection = conn;

    cmd.CommandText = "INSERT INTO myTable VALUES(NULL, @number, @text)";
    cmd.Prepare();

    cmd.Parameters.AddWithValue("@number", 1);
    cmd.Parameters.AddWithValue("@text", "One");

    for (int i=1; i <= 1000; i++)
    {
        cmd.Parameters["@number"].Value = i;
        cmd.Parameters["@text"].Value = "A string value";

        cmd.ExecuteNonQuery();
    }
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show("Error " + ex.Number + " has occurred: " + ex.Message,
        "Error", MessageBoxButtons.OK, MessageBoxIcon.Error);
}
```

Visual Basic Code Example

```
Dim conn As New MySqlConnection
Dim cmd As New MySqlCommand

conn.ConnectionString = strConnection

Try
   conn.Open()
   cmd.Connection = conn

   cmd.CommandText = "INSERT INTO myTable VALUES(NULL, @number, @text)"
   cmd.Prepare()

   cmd.Parameters.AddWithValue("@number", 1)
   cmd.Parameters.AddWithValue("@text", "One")

   For i = 1 To 1000
       cmd.Parameters("@number").Value = i
       cmd.Parameters("@text").Value = "A string value"

       cmd.ExecuteNonQuery()
     Next
Catch ex As MySqlException
    MessageBox.Show("Error " & ex.Number & " has occurred: " &
    ex.Message, "Error", MessageBoxButtons.OK, MessageBoxIcon.Error)
End Try
```

5.5 Creating and Calling Stored Procedures

A stored procedure is a set of SQL statements that is stored in the server. Clients make a single call to the stored procedure, passing parameters that can influence the procedure logic and query conditions, rather than issuing individual hardcoded SQL statements.

Stored procedures can be particularly useful in situations such as the following:

- Stored procedures can act as an API or abstraction layer, allowing multiple client applications to perform the same database operations. The applications can be written in different languages and run on different platforms. The applications do not need to hardcode table and column names, complicated queries, and so on. When you extend and optimize the queries in a stored procedure, all the applications that call the procedure automatically receive the benefits.

- When security is paramount, stored procedures keep applications from directly manipulating tables, or even knowing details such as table and column names. Banks, for example, use stored procedures for all common operations. This provides a consistent and secure environment, and procedures can ensure that each operation is properly logged. In such a setup, applications and users would not get any access to the database tables directly, but can only execute specific stored procedures.

This section does not provide in-depth information on creating stored procedures. For such information, see Using Stored Routines.

Creating a Stored Procedure

Stored procedures in MySQL can be created using a variety of tools, such as:

- The `mysql` command-line client
- MySQL Workbench
- The `MySqlCommand` object

Unlike the command-line and GUI clients, you are not required to specify a special delimiter when creating stored procedures in Connector/NET using the `MySqlCommand` class. For example, to create a stored procedure named `add_emp`, use the `CommandText` property with the default command type (SQL text commands) to execute each individual SQL statement in the context of your command that has an open connection to a server.

```
cmd.CommandText = "DROP PROCEDURE IF EXISTS add_emp";
cmd.ExecuteNonQuery();
cmd.CommandText = "DROP TABLE IF EXISTS emp";
cmd.ExecuteNonQuery();
cmd.CommandText = "CREATE TABLE emp ( +
                  "empno INT UNSIGNED NOT NULL AUTO_INCREMENT PRIMARY KEY, first_name VARCHAR(20)," +
                  "last_name VARCHAR(20), birthdate DATE)";
cmd.ExecuteNonQuery();

cmd.CommandText = "CREATE PROCEDURE add_emp(" +
                  "IN fname VARCHAR(20), IN lname VARCHAR(20), IN bday DATETIME, OUT empno INT)" +
                  "BEGIN INSERT INTO emp(first_name, last_name, birthdate) " +
                  "VALUES(fname, lname, DATE(bday)); SET empno = LAST_INSERT_ID(); END";
cmd.ExecuteNonQuery();
```

Accessing a Stored Procedure

After the stored procedure is named, you define one `MySqlCommand` parameter for every parameter in the stored procedure. `IN` parameters are defined with the parameter name and the object containing the value, `OUT` parameters are defined with the parameter name and the data type that is expected to be returned. All parameters need the parameter direction defined.

To call a stored procedure using Connector/NET, you create a `MySqlCommand` object and pass the stored procedure name as the `CommandText` property. You then set the `CommandType` property to `CommandType.StoredProcedure`. After defining the parameters, you call the stored procedure by using the `MySqlCommand.ExecuteNonQuery()` method.

```
cmd.CommandText = "add_emp";
cmd.CommandType = CommandType.StoredProcedure;

cmd.Parameters.AddWithValue("@lname", "Jones");
cmd.Parameters["@lname"].Direction = ParameterDirection.Input;

cmd.Parameters.AddWithValue("@fname", "Tom");
cmd.Parameters["@fname"].Direction = ParameterDirection.Input;
```

```
cmd.Parameters.AddWithValue("@bday", "1940-06-07");
cmd.Parameters["@bday"].Direction = ParameterDirection.Input;

cmd.Parameters.Add("@empno", MySqlDbType.Int32);
cmd.Parameters["@empno"].Direction = ParameterDirection.Output;

cmd.ExecuteNonQuery();
```

Connector/NET supports the calling of stored procedures through the `MySqlCommand` object. Data can be passed in and out of a MySQL stored procedure through use of the `MySqlCommand.Parameters` collection.

After the stored procedure is called, the values of the output parameters can be retrieved by using the `.Value` property of the `MySqlCommand.Parameters` collection.

```
Console.WriteLine("Employee number: "+cmd.Parameters["@empno"].Value);
Console.WriteLine("Birthday: " + cmd.Parameters["@bday"].Value);
```

> **Note**
>
> When a stored procedure is called using `MySqlCommand.ExecuteReader`, and the stored procedure has output parameters, the output parameters are set only after the `MySqlDataReader` returned by `ExecuteReader` is closed.

Stored Procedure Code Example

The following C# code example demonstrates the use of stored procedures. This example assumes the 'employees' database was created in advance:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;

using System.Data;
using MySql.Data;
using MySql.Data.MySqlClient;

namespace UsingStoredProcedures
{
    class Program
    {
        static void Main(string[] args)
        {
            MySqlConnection conn = new MySqlConnection();
            conn.ConnectionString = "server=localhost;user=root;database=employees;port=3306;password=******";
            MySqlCommand cmd = new MySqlCommand();

            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();
                cmd.Connection = conn;
                cmd.CommandText = "DROP PROCEDURE IF EXISTS add_emp";
                cmd.ExecuteNonQuery();
                cmd.CommandText = "DROP TABLE IF EXISTS emp";
                cmd.ExecuteNonQuery();
                cmd.CommandText = "CREATE TABLE emp (" +
                                  "empno INT UNSIGNED NOT NULL AUTO_INCREMENT PRIMARY KEY," +
                                  "first_name VARCHAR(20), last_name VARCHAR(20), birthdate DATE)";
                cmd.ExecuteNonQuery();

                cmd.CommandText = "CREATE PROCEDURE add_emp(" +
```

```
                                "IN fname VARCHAR(20), IN lname VARCHAR(20), IN bday DATETIME, OUT empno
                                "BEGIN INSERT INTO emp(first_name, last_name, birthdate) " +
                                "VALUES(fname, lname, DATE(bday)); SET empno = LAST_INSERT_ID(); END";

                cmd.ExecuteNonQuery();
            }
            catch (MySqlException ex)
            {
                Console.WriteLine ("Error " + ex.Number + " has occurred: " + ex.Message);
            }
            conn.Close();
            Console.WriteLine("Connection closed.");
            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();
                cmd.Connection = conn;

                cmd.CommandText = "add_emp";
                cmd.CommandType = CommandType.StoredProcedure;

                cmd.Parameters.AddWithValue("@lname", "Jones");
                cmd.Parameters["@lname"].Direction = ParameterDirection.Input;

                cmd.Parameters.AddWithValue("@fname", "Tom");
                cmd.Parameters["@fname"].Direction = ParameterDirection.Input;

                cmd.Parameters.AddWithValue("@bday", "1940-06-07");
                cmd.Parameters["@bday"].Direction = ParameterDirection.Input;

                cmd.Parameters.Add("@empno", MySqlDbType.Int32);
                cmd.Parameters["@empno"].Direction = ParameterDirection.Output;

                cmd.ExecuteNonQuery();

                Console.WriteLine("Employee number: "+cmd.Parameters["@empno"].Value);
                Console.WriteLine("Birthday: " + cmd.Parameters["@bday"].Value);
            }
            catch (MySql.Data.MySqlClient.MySqlException ex)
            {
                Console.WriteLine("Error " + ex.Number + " has occurred: " + ex.Message);
            }
            conn.Close();
            Console.WriteLine("Done.");
        }
    }
}
```

The following code shows the same application in Visual Basic:

```
Imports System
Imports System.Collections.Generic
Imports System.Linq
Imports System.Text

Imports System.Data
Imports MySql.Data
Imports MySql.Data.MySqlClient

Module Module1

    Sub Main()
        Dim conn As New MySqlConnection()
        conn.ConnectionString = "server=localhost;user=root;database=world;port=3306;password=******"
        Dim cmd As New MySqlCommand()

        Try
```

```
            Console.WriteLine("Connecting to MySQL...")
            conn.Open()
            cmd.Connection = conn
            cmd.CommandText = "DROP PROCEDURE IF EXISTS add_emp"
            cmd.ExecuteNonQuery()
            cmd.CommandText = "DROP TABLE IF EXISTS emp"
            cmd.ExecuteNonQuery()
            cmd.CommandText = "CREATE TABLE emp (" &
                              "empno INT UNSIGNED NOT NULL AUTO_INCREMENT PRIMARY KEY,
                              "first_name VARCHAR(20), last_name VARCHAR(20), birthdate DATE)"
            cmd.ExecuteNonQuery()

            cmd.CommandText = "CREATE PROCEDURE add_emp(" &
                              "IN fname VARCHAR(20), IN lname VARCHAR(20), IN bday DATETIME, OUT empno INT)" &
                              "BEGIN INSERT INTO emp(first_name, last_name, birthdate) " &
                              "VALUES(fname, lname, DATE(bday)); SET empno = LAST_INSERT_ID(); END"

            cmd.ExecuteNonQuery()
        Catch ex As MySqlException
            Console.WriteLine(("Error " & ex.Number & " has occurred: ") + ex.Message)
        End Try
        conn.Close()
        Console.WriteLine("Connection closed.")
        Try
            Console.WriteLine("Connecting to MySQL...")
            conn.Open()
            cmd.Connection = conn

            cmd.CommandText = "add_emp"
            cmd.CommandType = CommandType.StoredProcedure

            cmd.Parameters.AddWithValue("@lname", "Jones")
            cmd.Parameters("@lname").Direction = ParameterDirection.Input

            cmd.Parameters.AddWithValue("@fname", "Tom")
            cmd.Parameters("@fname").Direction = ParameterDirection.Input

            cmd.Parameters.AddWithValue("@bday", "1940-06-07")
            cmd.Parameters("@bday").Direction = ParameterDirection.Input

            cmd.Parameters.Add("@empno", MySqlDbType.Int32)
            cmd.Parameters("@empno").Direction = ParameterDirection.Output

            cmd.ExecuteNonQuery()

            Console.WriteLine("Employee number: " & cmd.Parameters("@empno").Value)
            Console.WriteLine("Birthday: " & cmd.Parameters("@bday").Value)
        Catch ex As MySql.Data.MySqlClient.MySqlException
            Console.WriteLine(("Error " & ex.Number & " has occurred: ") + ex.Message)
        End Try
        conn.Close()
        Console.WriteLine("Done.")

    End Sub

End Module
```

5.6 Handling BLOB Data With Connector/NET

One common use for MySQL is the storage of binary data in `BLOB` columns. MySQL supports four different BLOB data types: `TINYBLOB`, `BLOB`, `MEDIUMBLOB`, and `LONGBLOB`, all described in The BLOB and TEXT Types and Data Type Storage Requirements.

Data stored in a `BLOB` column can be accessed using MySQL Connector/NET and manipulated using client-side code. There are no special requirements for using Connector/NET with `BLOB` data.

Simple code examples will be presented within this section, and a full sample application can be found in the `Samples` directory of the Connector/NET installation.

5.6.1 Preparing the MySQL Server

The first step is using MySQL with `BLOB` data is to configure the server. To start, create a table that can be accessed. File tables often have four columns: an `AUTO_INCREMENT` column of appropriate size (`UNSIGNED SMALLINT`) to serve as a primary key to identify the file, a `VARCHAR` column that stores the file name, an `UNSIGNED MEDIUMINT` column that stores the size of the file, and a `MEDIUMBLOB` column that stores the file itself. For this example, use the following table definition:

```
CREATE TABLE file(
file_id SMALLINT UNSIGNED AUTO_INCREMENT NOT NULL PRIMARY KEY,
file_name VARCHAR(64) NOT NULL,
file_size MEDIUMINT UNSIGNED NOT NULL,
file MEDIUMBLOB NOT NULL);
```

After creating a table, you might need to modify the `max_allowed_packet` system variable. This variable determines how large of a packet (that is, a single row) can be sent to the MySQL server. By default, the server only accepts a maximum size of 1MB from the client application. If you intend to exceed 1MB in your file transfers, increase this number.

The `max_allowed_packet` option can be modified using the MySQL Workbench **Server Administration** screen. Adjust the Maximum permitted option in the **Data / Memory size** section of the Networking tab to an appropriate setting. After adjusting the value, click the **Apply** button and restart the server using the `Startup / Shutdown` screen of MySQL Workbench. You can also adjust this value directly in the `my.cnf` file (add a line that reads `max_allowed_packet=`*`xx`*`M`), or use the `SET max_allowed_packet=`*`xx`*`M;` syntax from within MySQL.

Try to be conservative when setting `max_allowed_packet`, as transfers of BLOB data can take some time to complete. Try to set a value that will be adequate for your intended use and increase the value if necessary.

5.6.2 Writing a File to the Database

To write a file to a database, we need to convert the file to a byte array, then use the byte array as a parameter to an `INSERT` query.

The following code opens a file using a FileStream object, reads it into a byte array, and inserts it into the `file` table:

C# Code Example

```
MySql.Data.MySqlClient.MySqlConnection conn;
MySql.Data.MySqlClient.MySqlCommand cmd;

conn = new MySql.Data.MySqlClient.MySqlConnection();
cmd = new MySql.Data.MySqlClient.MySqlCommand();

string SQL;
UInt32 FileSize;
byte[] rawData;
FileStream fs;

conn.ConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test";

try
{
    fs = new FileStream(@"c:\image.png", FileMode.Open, FileAccess.Read);
```

```
    FileSize = fs.Length;

    rawData = new byte[FileSize];
    fs.Read(rawData, 0, FileSize);
    fs.Close();

    conn.Open();

    SQL = "INSERT INTO file VALUES(NULL, @FileName, @FileSize, @File)";

    cmd.Connection = conn;
    cmd.CommandText = SQL;
    cmd.Parameters.AddWithValue("@FileName", strFileName);
    cmd.Parameters.AddWithValue("@FileSize", FileSize);
    cmd.Parameters.AddWithValue("@File", rawData);

    cmd.ExecuteNonQuery();

    MessageBox.Show("File Inserted into database successfully!",
        "Success!", MessageBoxButtons.OK, MessageBoxIcon.Asterisk);

    conn.Close();
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show("Error " + ex.Number + " has occurred: " + ex.Message,
        "Error", MessageBoxButtons.OK, MessageBoxIcon.Error);
}
```

Visual Basic Code Example

```
Dim conn As New MySqlConnection
Dim cmd As New MySqlCommand

Dim SQL As String

Dim FileSize As UInt32
Dim rawData() As Byte
Dim fs As FileStream

conn.ConnectionString = "server=127.0.0.1;" _
    & "uid=root;" _
    & "pwd=12345;" _
    & "database=test"

Try
    fs = New FileStream("c:\image.png", FileMode.Open, FileAccess.Read)
    FileSize = fs.Length

    rawData = New Byte(FileSize) {}
    fs.Read(rawData, 0, FileSize)
    fs.Close()

    conn.Open()

    SQL = "INSERT INTO file VALUES(NULL, @FileName, @FileSize, @File)"

    cmd.Connection = conn
    cmd.CommandText = SQL
    cmd.Parameters.AddWithValue("@FileName", strFileName)
    cmd.Parameters.AddWithValue("@FileSize", FileSize)
    cmd.Parameters.AddWithValue("@File", rawData)

    cmd.ExecuteNonQuery()

    MessageBox.Show("File Inserted into database successfully!", _
    "Success!", MessageBoxButtons.OK, MessageBoxIcon.Asterisk)
```

```
    conn.Close()
Catch ex As Exception
    MessageBox.Show("There was an error: " & ex.Message, "Error", _
        MessageBoxButtons.OK, MessageBoxIcon.Error)
End Try
```

The `Read` method of the `FileStream` object is used to load the file into a byte array which is sized according to the `Length` property of the `FileStream` object.

After assigning the byte array as a parameter of the `MySqlCommand` object, the `ExecuteNonQuery` method is called and the `BLOB` is inserted into the `file` table.

5.6.3 Reading a BLOB from the Database to a File on Disk

After a file is loaded into the `file` table, we can use the `MySqlDataReader` class to retrieve it.

The following code retrieves a row from the `file` table, then loads the data into a `FileStream` object to be written to disk:

C# Code Example

```
MySql.Data.MySqlClient.MySqlConnection conn;
MySql.Data.MySqlClient.MySqlCommand cmd;
MySql.Data.MySqlClient.MySqlDataReader myData;

conn = new MySql.Data.MySqlClient.MySqlConnection();
cmd = new MySql.Data.MySqlClient.MySqlCommand();

string SQL;
UInt32 FileSize;
byte[] rawData;
FileStream fs;

conn.ConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test";

SQL = "SELECT file_name, file_size, file FROM file";

try
{
    conn.Open();

    cmd.Connection = conn;
    cmd.CommandText = SQL;

    myData = cmd.ExecuteReader();

    if (! myData.HasRows)
        throw new Exception("There are no BLOBs to save");

    myData.Read();

    FileSize = myData.GetUInt32(myData.GetOrdinal("file_size"));
    rawData = new byte[FileSize];

    myData.GetBytes(myData.GetOrdinal("file"), 0, rawData, 0, (int)FileSize);

    fs = new FileStream(@"C:\newfile.png", FileMode.OpenOrCreate, FileAccess.Write);
    fs.Write(rawData, 0, (int)FileSize);
    fs.Close();

    MessageBox.Show("File successfully written to disk!",
        "Success!", MessageBoxButtons.OK, MessageBoxIcon.Asterisk);
```

```
    myData.Close();
    conn.Close();
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show("Error " + ex.Number + " has occurred: " + ex.Message,
        "Error", MessageBoxButtons.OK, MessageBoxIcon.Error);
}
```

Visual Basic Code Example

```
Dim conn As New MySqlConnection
Dim cmd As New MySqlCommand
Dim myData As MySqlDataReader
Dim SQL As String
Dim rawData() As Byte
Dim FileSize As UInt32
Dim fs As FileStream

conn.ConnectionString = "server=127.0.0.1;" _
    & "uid=root;" _
    & "pwd=12345;" _
    & "database=test"

SQL = "SELECT file_name, file_size, file FROM file"

Try
    conn.Open()

    cmd.Connection = conn
    cmd.CommandText = SQL

    myData = cmd.ExecuteReader

    If Not myData.HasRows Then Throw New Exception("There are no BLOBs to save")

    myData.Read()

    FileSize = myData.GetUInt32(myData.GetOrdinal("file_size"))
    rawData = New Byte(FileSize) {}

    myData.GetBytes(myData.GetOrdinal("file"), 0, rawData, 0, FileSize)

    fs = New FileStream("C:\newfile.png", FileMode.OpenOrCreate, FileAccess.Write)
    fs.Write(rawData, 0, FileSize)
    fs.Close()

    MessageBox.Show("File successfully written to disk!", "Success!", MessageBoxButtons.OK, MessageBoxIcon.Ast

    myData.Close()
    conn.Close()
Catch ex As Exception
    MessageBox.Show("There was an error: " & ex.Message, "Error", MessageBoxButtons.OK, MessageBoxIcon.Error)
End Try
```

After connecting, the contents of the `file` table are loaded into a `MySqlDataReader` object. The `GetBytes` method of the `MySqlDataReader` is used to load the `BLOB` into a byte array, which is then written to disk using a `FileStream` object.

The `GetOrdinal` method of the MySqlDataReader can be used to determine the integer index of a named column. Use of the GetOrdinal method prevents errors if the column order of the `SELECT` query is changed.

5.7 Working with Partial Trust / Medium Trust

.NET applications operate under a given trust level. Normal desktop applications operate under full trust, while web applications that are hosted in shared environments are normally run under the partial trust level (also known as “medium trust”). Some hosting providers host shared applications in their own app pools and allow the application to run under full trust, but this configuration is relatively rare. The MySQL Connector/NET support for partial trust has improved over time to simplify the configuration and deployment process for hosting providers.

5.7.1 Evolution of Partial Trust Support Across Connector/NET Versions

The partial trust support for MySQL Connector/NET has improved rapidly throughout the 6.5.x and 6.6.x versions. The latest enhancements do require some configuration changes in existing deployments. Here is a summary of the changes for each version.

6.6.4 and Above: Library Can Be Inside or Outside GAC

Now you can install the `MySql.Data.dll` library in the Global Assembly Cache (GAC) as explained in Section 5.7.2, “Configuring Partial Trust with Connector/NET Library Installed in GAC”, or in a `bin` or `lib` folder inside the project or solution as explained in Section 5.7.3, “Configuring Partial Trust with Connector/NET Library Not Installed in GAC”. If the library is not in the GAC, the only protocol supported is TCP/IP.

6.5.1 and Above: Partial Trust Requires Library in the GAC

Connector/NET 6.5 fully enables our provider to run in a partial trust environment when the library is installed in the Global Assembly Cache (GAC). The new `MySqlClientPermission` class, derived from the .NET `DBDataPermission` class, helps to simplify the permission setup.

5.0.8 / 5.1.3 and Above: Partial Trust Requires Socket Permissions

Starting with these versions, Connector/NET can be used under partial trust hosting that has been modified to allow the use of sockets for communication. By default, partial trust does not include `SocketPermission`. Connector/NET uses sockets to talk with the MySQL server, so the hosting provider must create a new trust level that is an exact clone of partial trust but that has the following permissions added:

- `System.Net.SocketPermission`
- `System.Security.Permissions.ReflectionPermission`
- `System.Net.DnsPermission`
- `System.Security.Permissions.SecurityPermission`

Prior to 5.0.8 / 5.1.3: Partial Trust Not Supported

Connector/NET versions prior to 5.0.8 and 5.1.3 were not compatible with partial trust hosting.

5.7.2 Configuring Partial Trust with Connector/NET Library Installed in GAC

If the library is installed in the GAC, you must include the connection option `includesecurityasserts=true` in your connection string. This is a new requirement as of MySQL Connector/NET 6.6.4.

The following list shows steps and code fragments needed to run a Connector/NET application in a partial trust environment. For illustration purposes, we use the Pipe Connections protocol in this example.

1. Install Connector/NET: version 6.6.1 or later, or 6.5.4 or later.
2. After installing the library, make the following configuration changes:

In the `SecurityClasses` section, add a definition for the `MySqlClientPermission` class, including the version to use.

```
<configuration>
  <mscorlib>
    <security>
      <policy>
        <PolicyLevel version="1">
          <SecurityClasses>
            ....
            <SecurityClass Name="MySqlClientPermission" Description="MySql.Data.MySqlClient.MySqlClientPerm
            MySql.Data, Version=6.6.4.0, Culture=neutral, PublicKeyToken=c5687fc88969c44d" />
```

Scroll down to the `ASP.Net` section:

```
<PermissionSet  class="NamedPermissionSet"  version="1"  Name="ASP.Net">
```

Add a new entry for the detailed configuration of the `MySqlClientPermission` class:

```
<IPermission class="MySqlClientPermission" version="1" Unrestricted="true"/>
```

> **Note**
>
> This configuration is the most generalized way that includes all keywords.

3. Configure the MySQL server to accept pipe connections, by adding the `--enable-named-pipe` option on the command line. If you need more information about this, see Installing MySQL on Microsoft Windows.

4. Confirm that the hosting provider has installed the Connector/NET library (`MySql.Data.dll`) in the GAC.

5. Optionally, the hosting provider can avoid granting permissions globally by using the new `MySqlClientPermission` class in the trust policies. (The alternative is to globally enable the permissions `System.Net.SocketPermission`, `System.Security.Permissions.ReflectionPermission`, `System.Net.DnsPermission`, and `System.Security.Permissions.SecurityPermission`.)

6. Create a simple web application using Visual Studio 2010.

7. Add the reference in your application for the `MySql.Data.MySqlClient` library.

8. Edit your `web.config` file so that your application runs using a Medium trust level:

```
<system.web>
  <trust level="Medium"/>
</system.web>
```

9. Add the `MySql.Data.MySqlClient` namespace to your server-code page.

10. Define the connection string, in slightly different ways depending on the Connector/NET version.

    Only for 6.6.4 or later: To use the connections inside any web application that will run in Medium trust, add the new `includesecurityasserts` option to the connection string. `includesecurityasserts=true` that makes the library request the following permissions when required: `SocketPermissions`, `ReflectionPermissions`, `DnsPermissions`, `SecurityPermissions` among others that are not granted in Medium trust levels.

    For Connector/NET 6.6.3 or earlier: No special setting for security is needed within the connection string.

```
MySqlConnectionStringBuilder myconnString = new MySqlConnectionStringBuilder("server=localhost;User Id=
myconnString.PipeName = "MySQL55";
myconnString.ConnectionProtocol = MySqlConnectionProtocol.Pipe;
// Following attribute is a new requirement when the library is in the GAC.
// Could also be done by adding includesecurityasserts=true; to the string literal
// in the constructor above.
// Not needed with Connector/NET 6.6.3 and earlier.
myconnString.IncludeSecurityAsserts = true;
```

11. Define the `MySqlConnection` to use:

```
MySqlConnection myconn = new MySqlConnection(myconnString.ConnectionString);
myconn.Open();
```

12. Retrieve some data from your tables:

```
MySqlCommand cmd = new MySqlCommand("Select * from products", myconn);
MySqlDataAdapter da = new MySqlDataAdapter(cmd);
DataSet1 tds = new DataSet1();
da.Fill(tds, tds.Tables[0].TableName);
GridView1.DataSource = tds;
GridView1.DataBind();
myconn.Close()
```

13. Run the program. It should execute successfully, without requiring any special code or encountering any security problems.

5.7.3 Configuring Partial Trust with Connector/NET Library Not Installed in GAC

When deploying a web application to a Shared Hosted environment, where this environment is configured to run all their .NET applications under a partial or medium trust level, you might not be able to install the MySQL Connector/NET library in the GAC. Instead, you put a reference to the library in the `bin` or `lib` folder inside the project or solution. In this case, you configure the security in a different way than when the library is in the GAC.

Connector/NET is commonly used by applications that run in Windows environments where the default communication for the protocol is used via sockets or by TCP/IP. For this protocol to operate is necessary have the required socket permissions in the web configuration file as follows:

1. Open the medium trust policy web configuration file, which should be under this folder:

   ```
   %windir%\Microsoft.NET\Framework\{version}\CONFIG\web_mediumtrust.config
   ```

   Use `Framework64` in the path instead of `Framework` if you are using a 64-bit installation of the framework.

2. Locate the `SecurityClasses` tag:

   ```
   <SecurityClass Name="SocketPermission"
   Description="System.Net.SocketPermission, System, Version=4.0.0.0,
   Culture=neutral, PublicKeyToken=b77a5c561934e089"/>
   ```

3. Scroll down and look for the following `PermissionSet`:

   ```
   <PermissionSet version="1" Name="ASP.Net">
   ```

4. Add the following inside this `PermissionSet`:

   ```
   <IPermission class="SocketPermission" version="1" Unrestricted="true" />
   ```

This configuration lets you use the driver with the default Windows protocol TCP/IP without having any security issues. This approach only supports the TCP/IP protocol, so you cannot use any other type of connection.

Also, since the `MySQLClientPermissions` class is not added to the medium trust policy, you cannot use it. This configuration is the minimum required in order to work with Connector/NET without the GAC.

5.8 Writing a Custom Authentication Plugin

Advanced users with special security requirements can create their own authentication plugins for MySQL Connector/NET applications. You can extend the handshake protocol, adding custom logic. For background and usage information about MySQL authentication plugins, see Authentication Plugins and Writing Authentication Plugins.

To write a custom authentication plugin, you will need a reference to the assembly `MySql.Data.dll`. The classes relevant for writing authentication plugins are available at the namespace `MySql.Data.MySqlClient.Authentication`.

How the Custom Authentication Plugin Works

At some point during handshake, the internal method

```
void Authenticate(bool reset)
```

of `MySqlAuthenticationPlugin` is called. This method in turns calls several overridable methods of the current plugin.

Creating the Authentication Plugin Class

You put the authentication plugin logic inside a new class derived from `MySql.Data.MySqlClient.Authentication.MySqlAuthenticationPlugin`. The following methods are available to be overridden:

```
protected virtual void CheckConstraints()
protected virtual void AuthenticationFailed(Exception ex)
protected virtual void AuthenticationSuccessful()
protected virtual byte[] MoreData(byte[] data)
protected virtual void AuthenticationChange()
public abstract string PluginName { get; }
public virtual string GetUsername()
public virtual object GetPassword()
protected byte[] AuthData;
```

The following is a brief explanation of each one:

```
/// <summary>
/// This method must check authentication method specific constraints in the
environment and throw an Exception
/// if the conditions are not met. The default implementation does nothing.
/// </summary>
protected virtual void CheckConstraints()

/// <summary>
/// This method, called when the authentication failed, provides a chance to
plugins to manage the error
/// the way they consider decide (either showing a message, logging it, etc.).
/// The default implementation wraps the original exception in a MySqlException
with an standard message and rethrows it.
/// </summary>
/// <param name="ex">The exception with extra information on the error.</param>
```

```
protected virtual void AuthenticationFailed(Exception ex)

/// <summary>
/// This method is invoked when the authentication phase was successful accepted
by the server.
/// Derived classes must override this if they want to be notified of such
condition.
/// </summary>
/// <remarks>The default implementation does nothing.</remarks>
protected virtual void AuthenticationSuccessful()

/// <summary>
/// This method provides a chance for the plugin to send more data when the
server requests so during the
/// authentication phase. This method will be called at least once, and more
than one depending upon whether the
/// server response packets have the 0x01 prefix.
/// </summary>
/// <param name="data">The response data from the server, during the
authentication phase the first time is called is null, in
subsequent calls contains the server response.</param>
/// <returns>The data generated by the plugin for server consumption.</returns>
/// <remarks>The default implementation always returns null.</remarks>
protected virtual byte[] MoreData(byte[] data)

/// <summary>
/// The plugin name.
/// </summary>
public abstract string PluginName { get; }

/// <summary>
/// Gets the user name to send to the server in the authentication phase.
/// </summary>
/// <returns>An string with the user name</returns>
/// <remarks>Default implementation returns the UserId passed from the
connection string.</remarks>
public virtual string GetUsername()

/// <summary>
/// Gets the password to send to the server in the authentication phase. This
can be a string or a
/// </summary>
/// <returns>An object, can be byte[], string or null, with the password.
</returns>
/// <remarks>Default implementation returns null.</remarks>
public virtual object GetPassword()

/// <summary>
/// The authentication data passed when creating the plugin.
/// For example in mysql_native_password this is the seed to encrypt the
password.
/// </summary>
protected byte[] AuthData;
```

Authentication Plugin Example

This example shows how to create the authentication plugin and then enable it by means of a configuration file.

1. Create a console app, adding a reference to `MySql.Data.dll`.
2. Design the main C# program as follows:

```
using System;
using System.Collections.Generic;
using System.Linq;
```

```
using System.Text;
using MySql.Data.MySqlClient;

namespace AuthPluginTest
{
  class Program
  {
    static void Main(string[] args)
    {
      // Customize the connection string as necessary.
      MySqlConnection con = new MySqlConnection("server=localhost;
      database=test; user id=myuser; password=mypass");
      con.Open();
      con.Close();
    }
  }
}
```

3. Create your plugin class. In this example, we add an “alternative” implementation of the Native password plugin by just using the same code from the original plugin. We name our class `MySqlNativePasswordPlugin2`:

```
using System.IO;
using System;
using System.Text;
using System.Security.Cryptography;
using MySql.Data.MySqlClient.Authentication;
using System.Diagnostics;

namespace AuthPluginTest
{
  public class MySqlNativePasswordPlugin2 : MySqlAuthenticationPlugin
  {
    public override string PluginName
    {
      get { return "mysql_native_password"; }
    }

    public override object GetPassword()
    {
      Debug.WriteLine("Calling MySqlNativePasswordPlugin2.GetPassword");
      return Get411Password(Settings.Password, AuthData);
    }

    /// <summary>
    /// Returns a byte array containing the proper encryption of the
    /// given password/seed according to the new 4.1.1 authentication scheme.
    /// </summary>
    /// <param name="password"></param>
    /// <param name="seed"></param>
    /// <returns></returns>
    private byte[] Get411Password(string password, byte[] seedBytes)
    {
      // if we have no password, then we just return 1 zero byte
      if (password.Length == 0) return new byte[1];

      SHA1 sha = new SHA1CryptoServiceProvider();

      byte[] firstHash = sha.ComputeHash(Encoding.Default.GetBytes(password));
      byte[] secondHash = sha.ComputeHash(firstHash);

      byte[] input = new byte[seedBytes.Length + secondHash.Length];
      Array.Copy(seedBytes, 0, input, 0, seedBytes.Length);
      Array.Copy(secondHash, 0, input, seedBytes.Length, secondHash.Length);
      byte[] thirdHash = sha.ComputeHash(input);
```

```
      byte[] finalHash = new byte[thirdHash.Length + 1];
      finalHash[0] = 0x14;
      Array.Copy(thirdHash, 0, finalHash, 1, thirdHash.Length);

      for (int i = 1; i < finalHash.Length; i++)
        finalHash[i] = (byte)(finalHash[i] ^ firstHash[i - 1]);
      return finalHash;
    }
  }
}
```

Notice that the plugin implementation just overrides `GetPassword`, and provides an implementation to encrypt the password using the 4.1 protocol. Add the following line in the `GetPassword` body to provide confirmation that the plugin was effectively used.

```
Debug.WriteLine("Calling MySqlNativePasswordPlugin2.GetPassword");
```

> **Tip**
>
> You could also put a breakpoint on that method.

4. Enable the new plugin in the configuration file:

```
<?xml version="1.0"?>
<configuration>
  <configSections>
    <section name="MySQL" type="MySql.Data.MySqlClient.MySqlConfiguration,
MySql.Data"/>
  </configSections>
  <MySQL>
    <AuthenticationPlugins>
      <add name="mysql_native_password"
type="AuthPluginTest.MySqlNativePasswordPlugin2, AuthPluginTest"></add>
    </AuthenticationPlugins>
  </MySQL>
<startup><supportedRuntime version="v4.0" sku=".NETFramework,Version=v4.0"/>
</startup></configuration>
```

5. Run the application. In Visual Studio, you will see the message `Calling MySqlNativePasswordPlugin2.GetPassword` in the debug window.

Continue enhancing the authentication logic, overriding more methods if you required.

5.9 Using the Connector/NET Interceptor Classes

An interceptor is a software design pattern that provides a transparent way to extend or modify some aspect of a program, similar to a user exit. No recompiling is required. With MySQL Connector/NET, the interceptors are enabled and disabled by updating the connection string to refer to different sets of interceptor classes that you instantiate.

> **Note**
>
> The classes and methods presented in this section do not apply to Connector/NET applications developed with the .NET Core 1.1 framework.

Connector/NET includes the following interceptor classes:

- The `BaseCommandInterceptor` lets you perform additional operations when a program issues a SQL command. For example, you can examine the SQL statement for logging or debugging purposes, substitute your own result set to implement a caching mechanism, and so on. Depending on the use case, your code can supplement the SQL command or replace it entirely.

The `BaseCommandInterceptor` class has these methods that you can override:

```
public virtual bool ExecuteScalar(string sql, ref object returnValue);
public virtual bool ExecuteNonQuery(string sql, ref int returnValue);
public virtual bool ExecuteReader(string sql, CommandBehavior behavior, ref MySqlDataReader returnValue);
public virtual void Init(MySqlConnection connection);
```

If your interceptor overrides one of the `Execute...` methods, set the `returnValue` output parameter and return `true` if you handled the event, or `false` if you did not handle the event. The SQL command is processed normally only when all command interceptors return `false`.

The connection passed to the `Init` method is the connection that is attached to this interceptor.

- The `BaseExceptionInterceptor` lets you perform additional operations when a program encounters an SQL exception. The exception interception mechanism is modeled after the Connector/J model. You can code an interceptor class and connect it to an existing program without recompiling, and intercept exceptions when they are created. You can then change the exception type and optionally attach information to it. This capability lets you turn on and off logging and debugging code without hardcoding anything in the application. This technique applies to exceptions raised at the SQL level, not to lower-level system or I/O errors.

  You develop an exception interceptor first by creating a subclass of the `BaseExceptionInterceptor` class. You must override the `InterceptException()` method. You can also override the `Init()` method to do some one-time initialization.

  Each exception interceptor has 2 methods:

  ```
  public abstract Exception InterceptException(Exception exception,
    MySqlConnection connection);
  public virtual void Init(MySqlConnection connection);
  ```

  The connection passed to `Init()` is the connection that is attached to this interceptor.

  Each interceptor is required to override `InterceptException` and return an exception. It can return the exception it is given, or it can wrap it in a new exception. We currently do not offer the ability to suppress the exception.

Here are examples of using the FQN (fully qualified name) on the connection string:

```
MySqlConnection c1 = new MySqlConnection(@"server=localhost;pooling=false;
commandinterceptors=CommandApp.MyCommandInterceptor,CommandApp");

MySqlConnection c2 = new MySqlConnection(@"server=localhost;pooling=false;
exceptioninterceptors=ExceptionStackTraceTest.MyExceptionInterceptor,ExceptionStackTraceTest");
```

In this example, the command interceptor is called `CommandApp.MyCommandInterceptor` and exists in the `CommandApp` assembly. The exception interceptor is called `ExceptionStackTraceTest.MyExceptionInterceptor` and exists in the `ExceptionStackTraceTest` assembly.

To shorten the connection string, you can register your exception interceptors in your `app.config` or `web.config` file like this:

```
<configSections>
<section name="MySQL" type="MySql.Data.MySqlClient.MySqlConfiguration,MySql.Data"/>
</configSections>
<MySQL>
<CommandInterceptors>
  <add name="myC" type="CommandApp.MyCommandInterceptor,CommandApp" />
</CommandInterceptors>
```

```
</MySQL>

<configSections>
<section name="MySQL" type="MySql.Data.MySqlClient.MySqlConfiguration,
MySql.Data"/>
</configSections>
<MySQL>
<ExceptionInterceptors>
  <add name="myE"
  type="ExceptionStackTraceTest.MyExceptionInterceptor,ExceptionStackTraceTest" />
</ExceptionInterceptors>
</MySQL>
```

After you have done that, your connection strings can look like these:

```
MySqlConnection c1 = new MySqlConnection(@"server=localhost;pooling=false;
commandinterceptors=myC");

MySqlConnection c2 = new MySqlConnection(@"server=localhost;pooling=false;
exceptioninterceptors=myE");
```

5.10 Handling Date and Time Information in Connector/NET

MySQL and the .NET languages handle date and time information differently, with MySQL allowing dates that cannot be represented by a .NET data type, such as '`0000-00-00 00:00:00`'. These differences can cause problems if not properly handled.

The following sections demonstrate how to properly handle date and time information when using MySQL Connector/NET.

5.10.1 Fractional Seconds

MySQL Connector/NET supports the fractional seconds feature in MySQL, where the fractional seconds part of temporal values is preserved in data stored and retrieved through SQL. For fractional second handling in MySQL 5.6.4 and higher, see Fractional Seconds in Time Values.

To use the more precise date and time types, specify a value from 1 to 6 when creating the table column, for example `TIME(3)` or `DATETIME(6)`, representing the number of digits of precision after the decimal point. Specifying a precision of 0 leaves the fractional part out entirely. In your C# or Visual Basic code, refer to the `Millisecond` member to retrieve the fractional second value from the `MySqlDateTime` object returned by the `GetMySqlDateTime` function. The `DateTime` object returned by the `GetDateTime` function also contains the fractional value, but only the first 3 digits.

For related code examples, see the following blog post: https://blogs.oracle.com/MySqlOnWindows/entry/milliseconds_value_support_on_datetime

5.10.2 Problems when Using Invalid Dates

The differences in date handling can cause problems for developers who use invalid dates. Invalid MySQL dates cannot be loaded into native .NET `DateTime` objects, including `NULL` dates.

Because of this issue, .NET `DataSet` objects cannot be populated by the `Fill` method of the `MySqlDataAdapter` class as invalid dates will cause a `System.ArgumentOutOfRangeException` exception to occur.

5.10.3 Restricting Invalid Dates

The best solution to the date problem is to restrict users from entering invalid dates. This can be done on either the client or the server side.

Restricting invalid dates on the client side is as simple as always using the .NET `DateTime` class to handle dates. The `DateTime` class will only allow valid dates, ensuring that the values in your database are also valid. The disadvantage of this is that it is not useful in a mixed environment where .NET and non .NET code are used to manipulate the database, as each application must perform its own date validation.

Users of MySQL 5.0.2 and higher can use the new `traditional` SQL mode to restrict invalid date values. For information on using the `traditional` SQL mode, see Server SQL Modes.

5.10.4 Handling Invalid Dates

Although it is strongly recommended that you avoid the use of invalid dates within your .NET application, it is possible to use invalid dates by means of the `MySqlDateTime` data type.

The `MySqlDateTime` data type supports the same date values that are supported by the MySQL server. The default behavior of Connector/NET is to return a .NET DateTime object for valid date values, and return an error for invalid dates. This default can be modified to cause Connector/NET to return `MySqlDateTime` objects for invalid dates.

To instruct Connector/NET to return a `MySqlDateTime` object for invalid dates, add the following line to your connection string:

```
Allow Zero Datetime=True
```

The `MySqlDateTime` class can still be problematic. The following are some known issues:

- Data binding for invalid dates can still cause errors (zero dates like 0000-00-00 do not seem to have this problem).
- The `ToString` method return a date formatted in the standard MySQL format (for example, `2005-02-23 08:50:25`). This differs from the `ToString` behavior of the .NET DateTime class.
- The `MySqlDateTime` class supports NULL dates, while the .NET DateTime class does not. This can cause errors when trying to convert a MySQLDateTime to a DateTime if you do not check for NULL first.

Because of the known issues, the best recommendation is still to use only valid dates in your application.

5.10.5 Handling NULL Dates

The .NET `DateTime` data type cannot handle `NULL` values. As such, when assigning values from a query to a `DateTime` variable, you must first check whether the value is in fact `NULL`.

When using a `MySqlDataReader`, use the `.IsDBNull` method to check whether a value is `NULL` before making the assignment:

C# Code Example

```
if (! myReader.IsDBNull(myReader.GetOrdinal("mytime")))
    myTime = myReader.GetDateTime(myReader.GetOrdinal("mytime"));
else
    myTime = DateTime.MinValue;
```

Visual Basic Code Example

```
If Not myReader.IsDBNull(myReader.GetOrdinal("mytime")) Then
    myTime = myReader.GetDateTime(myReader.GetOrdinal("mytime"))
Else
    myTime = DateTime.MinValue
End If
```

`NULL` values will work in a data set and can be bound to form controls without special handling.

5.11 Using the MySqlBulkLoader Class

MySQL Connector/NET features a bulk loader class that wraps the MySQL statement `LOAD DATA INFILE`. This gives Connector/NET the ability to load a data file from a local or remote host to the server, or a stream to a database (from Connector/NET 8.0.32).

The class concerned is `MySqlBulkLoader`. This class has various methods, the main overloaded method being `load`, which permits a stream object to be loaded directly to a database (8.0.32) or the specified file to the server. Various parameters can be set to control how the data file is processed. This is achieved through setting various properties of the class. For example, the field separator used, such as comma or tab, can be specified, along with the record terminator, such as newline.

The following code shows a simple example of using the `MySqlBulkLoader` class. First an empty table needs to be created, in this case in the `test` database.

```
CREATE TABLE Career (
       Name VARCHAR(100) NOT NULL,
       Age INTEGER,
       Profession VARCHAR(200)
);
```

A simple tab-delimited data file is also created (it could use any other field delimiter such as comma).

```
Table Career in Test Database
Name  Age  Profession

Tony   47  Technical Writer
Ana    43  Nurse
Fred   21  IT Specialist
Simon  45  Hairy Biker
```

The first three lines need to be ignored with this test file, as they do not contain table data. This task is accomplished in the following C# code example by setting the `NumberOfLinesToSkip` property . The file can then be loaded and used to populate the `Career` table in the `test` database.

> **Note**
>
> As of Connector/NET 8.0.15, the `Local` property must be set to `True` explicitly to enable the local-infile capability. Previous versions set this value to `True` by default.

```
using System;
using System.Text;
using MySql.Data;
using MySql.Data.MySqlClient;

namespace ConsoleApplication1
{
    class Program
    {
        static void Main(string[] args)
        {

            string connStr = "server=localhost;user=root;database=test;port=3306;password=******";
            MySqlConnection conn = new MySqlConnection(connStr);

            MySqlBulkLoader bl = new MySqlBulkLoader(conn);
            bl.Local = true;
            bl.TableName = "Career";
            bl.FieldTerminator = "\t";
            bl.LineTerminator = "\n";
            bl.FileName = "c:/career_data.txt";
            bl.NumberOfLinesToSkip = 3;
```

```
            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();

                // Upload data from file
                int count = bl.Load();
                Console.WriteLine(count + " lines uploaded.");

                string sql = "SELECT Name, Age, Profession FROM Career";
                MySqlCommand cmd = new MySqlCommand(sql, conn);
                MySqlDataReader rdr = cmd.ExecuteReader();

                while (rdr.Read())
                {
                    Console.WriteLine(rdr[0] + " -- " + rdr[1] + " -- " + rdr[2]);
                }

                rdr.Close();

                conn.Close();
            }
            catch (Exception ex)
            {
                Console.WriteLine(ex.ToString());
            }
            Console.WriteLine("Done.");
        }
    }
}
```

Further information on `LOAD DATA INFILE` can be found in LOAD DATA Statement. Further information on `MySqlBulkLoader` can be found in the reference documentation that was included with your connector.

5.12 Connector/NET Tracing

5.12.1 Enabling OpenTelemetry Tracing

OpenTelementry (OTel) standardizes instrumentation, generation, collecting and exporting telemetry data to be consumed by an Observability backend. For more details on OpenTelemetry, visit its official site.

Starting in Connector/NET 8.1.0, support for OTel is encapsulated in the `MySQL.Data.OpenTelemetry` NuGet package. This package implements the functionality to add the connector to the tracer provider using `OpenTelementry.Api`. Connector/NET neither creates nor provides the means to create an OTel exporter. Instead, it relies on the default exporter supplied by your application.

> **Note**
>
> OTel context forwarding works only with MySQL Enterprise Edition, a commercial product. To learn more about commercial products, see https://www.mysql.com/products/.

Requirements for Enabling Tracing

- .NET 5 and later.
- Connector/NET 8.1.0 `MySQL.Data.OpenTelemetry` and `MySQL.Data` NuGet packages.

> **Note**
>
> The Connector/NET MSI file does not include support this OTel implementation.

- An OpenTelemetry SDK of your choosing and an appropriate exporter package.
- MySQL Enterprise Edition server with the query attributes enabled. If the server does not support query attributes or has them disabled, then Connector/NET skips the entire context propagation flow.
- Code that uses OTel instrumentation. If your code does not use instrumentation, then the connector does not forward the current OTel context for each executed statement.

Enabling OpenTelemetry

To enable OTel tracing using the Connector/NET implementation, add the connector to the trace provider builder as follows:

```
var tracerProvider = sdk.TraceProviderBuilder().AddConnectorNet().Build();
```

When you build code that links to Connector/NET and uses OTel instrumentation, the additional spans generated by the connector appear in the traces generated by your code. Spans generated by the connector are sent to the same destination (trace exporter) where other spans generated by the user code are sent as configured by user code. It is not possible to send spans generated by the connector to any other destination.

5.12.2 Using the Connector/NET Trace Source Object

The .NET tracing architecture consists of four main parts:

- *Source* - This is the originator of the trace information. The source is used to send trace messages. The name of the source provided by Connector/NET is `mysql`.
- *Switch* - This defines the level of trace information to emit. Typically, this is specified in the `app.config` file, so that it is not necessary to recompile an application to change the trace level.
- *Listener* - Trace listeners define where the trace information will be written to. Supported listeners include, for example, the Visual Studio Output window, the Windows Event Log, and the console.
- *Filter* - Filters can be attached to listeners. Filters determine the level of trace information that will be written. While a switch defines the level of information that will be written to all listeners, a filter can be applied on a per-listener basis, giving finer grained control of trace information.

To use tracing **MySql.Data.MySqlClient.MySqlTrace** can be used as a TraceSource for Connector/NET and the connection string must include *"Logging=True"*.

To enable trace messages, configure a trace switch. Trace switches have associated with them a trace level enumeration, these are **Off**, **Error**, **Warning**, **Info**, and **Verbose**.

```
MySqlTrace.Switch.Level = SourceLevels.Verbose;
```

This sets the trace level to **Verbose**, meaning that all trace messages will be written.

It is convenient to be able to change the trace level without having to recompile the code. This is achieved by specifying the trace level in application configuration file, `app.config`. You then simply need to specify the desired trace level in the configuration file and restart the application. The trace source is configured within the `system.diagnostics` section of the file. The following XML snippet illustrates this:

```
<configuration>
  ...
  <system.diagnostics>
    <sources>
      <source name="mysql" switchName="MySwitch"
              switchType="System.Diagnostics.SourceSwitch" />
      ...
    </sources>
```

```
    <switches>
      <add name="MySwitch" value="Verbose"/>
      ...
    </switches>
  </system.diagnostics>
  ...
</configuration>
```

By default, trace information is written to the Output window of Microsoft Visual Studio. There are a wide range of listeners that can be attached to the trace source, so that trace messages can be written out to various destinations. You can also create custom listeners to allow trace messages to be written to other destinations as mobile devices and web services. A commonly used example of a listener is `ConsoleTraceListener`, which writes trace messages to the console.

To add a listener at runtime, use code such as the following:

```
ts.Listeners.Add(new ConsoleTraceListener());
```

Then, call methods on the trace source object to generate trace information. For example, the `TraceInformation()`, `TraceEvent()`, or `TraceData()` methods can be used.

5.12.2.1 Viewing MySQL Trace Information

This section describes how to set up your application to view MySQL trace information.

The first thing you need to do is create a suitable `app.config` file for your application. For example:

```
<?xml version="1.0" encoding="utf-8" ?>
<configuration>
  <system.diagnostics>
    <sources>
      <source name="mysql" switchName="SourceSwitch"
        switchType="System.Diagnostics.SourceSwitch" >
        <listeners>
          <add name="console" />
          <remove name ="Default" />
        </listeners>
      </source>
    </sources>
    <switches>
      <!-- You can set the level at which tracing is to occur -->
      <add name="SourceSwitch" value="Verbose" />
      <!-- You can turn tracing off -->
      <!--add name="SourceSwitch" value="Off" -->
    </switches>
    <sharedListeners>
      <add name="console"
        type="System.Diagnostics.ConsoleTraceListener"
        initializeData="false"/>
    </sharedListeners>
  </system.diagnostics>
</configuration>
```

This configuration ensures that a suitable trace source is created, along with a switch. The switch level in this case is set to `Verbose` to display the maximum amount of information.

Next, add `logging=true` to the connection string in your C# application. For example:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Diagnostics;
using MySql.Data;
using MySql.Data.MySqlClient;
```

```
using MySql.Web;


namespace ConsoleApplication1
{
    class Program
    {
        static void Main(string[] args)
        {

            string connStr = "server=localhost;user=root;database=world;port=3306;password=******;logging=
            MySqlConnection conn = new MySqlConnection(connStr);
            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();

                string sql = "SELECT Name, HeadOfState FROM Country WHERE Continent='Oceania'";
                MySqlCommand cmd = new MySqlCommand(sql, conn);
                MySqlDataReader rdr = cmd.ExecuteReader();

                while (rdr.Read())
                {
                    Console.WriteLine(rdr[0] + " -- " + rdr[1]);
                }

                rdr.Close();

                conn.Close();
            }
            catch (Exception ex)
            {
                Console.WriteLine(ex.ToString());
            }
            Console.WriteLine("Done.");
        }
    }
}
```

This simple application then generates the following output:

```
Connecting to MySQL...
mysql Information: 1 : 1: Connection Opened: connection string = 'server=localhost;User Id=root;database=w
;password=******;logging=True'
mysql Information: 3 : 1: Query Opened: SHOW VARIABLES
mysql Information: 4 : 1: Resultset Opened: field(s) = 2, affected rows = -1, inserted id = -1
mysql Information: 5 : 1: Resultset Closed. Total rows=272, skipped rows=0, size (bytes)=7058
mysql Information: 6 : 1: Query Closed
mysql Information: 3 : 1: Query Opened: SHOW COLLATION
mysql Information: 4 : 1: Resultset Opened: field(s) = 6, affected rows = -1, inserted id = -1
mysql Information: 5 : 1: Resultset Closed. Total rows=127, skipped rows=0, size (bytes)=4102
mysql Information: 6 : 1: Query Closed
mysql Information: 3 : 1: Query Opened: SET character_set_results=NULL
mysql Information: 4 : 1: Resultset Opened: field(s) = 0, affected rows = 0, inserted id = 0
mysql Information: 5 : 1: Resultset Closed. Total rows=0, skipped rows=0, size (bytes)=0
mysql Information: 6 : 1: Query Closed
mysql Information: 10 : 1: Set Database: world
mysql Information: 3 : 1: Query Opened: SELECT Name, HeadOfState FROM Country WHERE Continent='Oceania'
mysql Information: 4 : 1: Resultset Opened: field(s) = 2, affected rows = -1, inserted id = -1
American Samoa -- George W. Bush
Australia -- Elisabeth II
...
Wallis and Futuna -- Jacques Chirac
Vanuatu -- John Bani
United States Minor Outlying Islands -- George W. Bush
mysql Information: 5 : 1: Resultset Closed. Total rows=28, skipped rows=0, size (bytes)=788
mysql Information: 6 : 1: Query Closed
```

```
Done.
mysql Information: 2 : 1: Connection Closed
```

The first number displayed in the trace message corresponds to the MySQL event type. The second number displayed in the trace message is the connection count. The following table describes each MySQL event type.

Event Type	Description
1	ConnectionOpened: connection string
2	ConnectionClosed:
3	QueryOpened: mysql server thread id, query text
4	ResultOpened: field count, affected rows (-1 if select), inserted id (-1 if select)
5	ResultClosed: total rows read, rows skipped, size of result set in bytes
6	QueryClosed:
7	StatementPrepared: prepared sql, statement id
8	StatementExecuted: statement id, mysql server thread id
9	StatementClosed: statement id
10	NonQuery: [varies]
11	UsageAdvisorWarning: usage advisor flag. NoIndex = 1, BadIndex = 2, SkippedRows = 3, SkippedColumns = 4, FieldConversion = 5.
12	Warning: level, code, message
13	Error: error number, error message

Although this example uses the `ConsoleTraceListener`, any of the other standard listeners can be used. Another possibility is to create a custom listener that uses the information passed in with the `TraceEvent` method. For example, a custom trace listener can be created to perform active monitoring of the MySQL event messages, rather than simply writing these to an output device.

It is also possible to add listeners to the MySQL Trace Source at runtime. This can be done with the following code:

```
MySqlTrace.Listeners.Add(new ConsoleTraceListener());
```

Connector/NET provides the ability to switch tracing on and off at runtime. This can be achieved using the calls `MySqlTrace.EnableQueryAnalyzer(string host, int postInterval)` and `MySqlTrace.DisableQueryAnalyzer()`. The parameter `host` is the URL of the MySQL Enterprise Monitor server to monitor. The parameter `postInterval` is how often to post the data to MySQL Enterprise Monitor, in seconds.

5.12.2.2 Building Custom Listeners

To build custom listeners that work with the MySQL Connector/NET Trace Source, it is necessary to understand the key methods used, and the event data formats used.

The main method involved in passing trace messages is the `TraceSource.TraceEvent` method. This has the prototype:

```
public void TraceEvent(
    TraceEventType eventType,
    int id,
    string format,
    params Object[] args
```

```
)
```

This trace source method will process the list of attached listeners and call the listener's `TraceListener.TraceEvent` method. The prototype for the `TraceListener.TraceEvent` method is as follows:

```
public virtual void TraceEvent(
    TraceEventCache eventCache,
    string source,
    TraceEventType eventType,
    int id,
    string format,
    params Object[] args
)
```

The first three parameters are used in the standard as defined by Microsoft. The last three parameters contain MySQL-specific trace information. Each of these parameters is now discussed in more detail.

`int id`

This is a MySQL-specific identifier. It identifies the MySQL event type that has occurred, resulting in a trace message being generated. This value is defined by the `MySqlTraceEventType` public enum contained in the Connector/NET code:

```
public enum MySqlTraceEventType : int
{
    ConnectionOpened = 1,
    ConnectionClosed,
    QueryOpened,
    ResultOpened,
    ResultClosed,
    QueryClosed,
    StatementPrepared,
    StatementExecuted,
    StatementClosed,
    NonQuery,
    UsageAdvisorWarning,
    Warning,
    Error
}
```

The MySQL event type also determines the contents passed using the parameter `params Object[] args`. The nature of the `args` parameters are described in further detail in the following material.

`string format`

This is the format string that contains zero or more format items, which correspond to objects in the args array. This would be used by a listener such as `ConsoleTraceListener` to write a message to the output device.

`params Object[] args`

This is a list of objects that depends on the MySQL event type, `id`. However, the first parameter passed using this list is always the driver id. The driver id is a unique number that is incremented each time the connector is opened. This enables groups of queries on the same connection to be identified. The parameters that follow driver id depend on the MySQL event id, and are as follows:

MySQL-specific event type	Arguments (params Object[] args)
ConnectionOpened	Connection string
ConnectionClosed	No additional parameters
QueryOpened	mysql server thread id, query text

MySQL-specific event type	Arguments (params Object[] args)
ResultOpened	field count, affected rows (-1 if select), inserted id (-1 if select)
ResultClosed	total rows read, rows skipped, size of result set in bytes
QueryClosed	No additional parameters
StatementPrepared	prepared sql, statement id
StatementExecuted	statement id, mysql server thread id
StatementClosed	statement id
NonQuery	Varies
UsageAdvisorWarning	usage advisor flag. NoIndex = 1, BadIndex = 2, SkippedRows = 3, SkippedColumns = 4, FieldConversion = 5.
Warning	level, code, message
Error	error number, error message

This information allows you to create custom trace listeners that can actively monitor the MySQL-specific events.

5.13 Using Connector/NET with Crystal Reports

Crystal Reports is a common tool used by Windows application developers to perform reporting and document generation. In this section we will show how to use Crystal Reports XI with MySQL and MySQL Connector/NET.

5.13.1 Creating a Data Source

When creating a report in Crystal Reports there are two options for accessing the MySQL data while designing your report.

The first option is to use Connector/ODBC as an ADO data source when designing your report. You will be able to browse your database and choose tables and fields using drag and drop to build your report. The disadvantage of this approach is that additional work must be performed within your application to produce a data set that matches the one expected by your report.

The second option is to create a data set in VB.NET and save it as XML. This XML file can then be used to design a report. This works quite well when displaying the report in your application, but is less versatile at design time because you must choose all relevant columns when creating the data set. If you forget a column you must re-create the data set before the column can be added to the report.

The following code can be used to create a data set from a query and write it to disk:

C# Code Example

```
DataSet myData = new DataSet();
MySql.Data.MySqlClient.MySqlConnection conn;
MySql.Data.MySqlClient.MySqlCommand cmd;
MySql.Data.MySqlClient.MySqlDataAdapter myAdapter;

conn = new MySql.Data.MySqlClient.MySqlConnection();
cmd = new MySql.Data.MySqlClient.MySqlCommand();
myAdapter = new MySql.Data.MySqlClient.MySqlDataAdapter();

conn.ConnectionString = "server=127.0.0.1;uid=root;" +
  "pwd=12345;database=test";

try
```

```
{
  cmd.CommandText = "SELECT city.name AS cityName, city.population AS CityPopulation, " +
  "country.name, country.population, country.continent " +
  "FROM country, city ORDER BY country.continent, country.name";
  cmd.Connection = conn;

  myAdapter.SelectCommand = cmd;
  myAdapter.Fill(myData);

  myData.WriteXml(@"C:\dataset.xml", XmlWriteMode.WriteSchema);
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
  MessageBox.Show(ex.Message, "Report could not be created",
  MessageBoxButtons.OK, MessageBoxIcon.Error);
}
```

Visual Basic Code Example

```
Dim myData As New DataSet
Dim conn As New MySqlConnection
Dim cmd As New MySqlCommand
Dim myAdapter As New MySqlDataAdapter

conn.ConnectionString = "server=127.0.0.1;" _
    & "uid=root;" _
    & "pwd=12345;" _
    & "database=world"

Try
    conn.Open()
    cmd.CommandText = "SELECT city.name AS cityName, city.population AS CityPopulation, " _
        & "country.name, country.population, country.continent " _
        & "FROM country, city ORDER BY country.continent, country.name"
    cmd.Connection = conn

    myAdapter.SelectCommand = cmd
    myAdapter.Fill(myData)

    myData.WriteXml("C:\dataset.xml", XmlWriteMode.WriteSchema)
Catch ex As Exception
    MessageBox.Show(ex.Message, "Report could not be created", MessageBoxButtons.OK, MessageBoxIcon.Error)
End Try
```

The resulting XML file can be used as an ADO.NET XML datasource when designing your report.

If you choose to design your reports using Connector/ODBC, it can be downloaded from dev.mysql.com.

5.13.2 Creating the Report

For most purposes, the Standard Report wizard helps with the initial creation of a report. To start the wizard, open Crystal Reports and choose the **New > Standard Report** option from the File menu.

The wizard first prompts you for a data source. If you use Connector/ODBC as your data source, use the OLEDB provider for ODBC option from the OLE DB (ADO) tree instead of the ODBC (RDO) tree when choosing a data source. If using a saved data set, choose the ADO.NET (XML) option and browse to your saved data set.

The remainder of the report creation process is done automatically by the wizard.

After the report is created, choose the **Report Options** entry from the **File** menu. Un-check the **Save Data With Report** option. This prevents saved data from interfering with the loading of data within our application.

5.13.3 Displaying the Report

To display a report we first populate a data set with the data needed for the report, then load the report and bind it to the data set. Finally we pass the report to the crViewer control for display to the user.

The following references are needed in a project that displays a report:

- CrystalDecisions.CrystalReports.Engine
- CrystalDecisions.ReportSource
- CrystalDecisions.Shared
- CrystalDecisions.Windows.Forms

The following code assumes that you created your report using a data set saved using the code shown in Section 5.13.1, “Creating a Data Source”, and have a crViewer control on your form named `myViewer`.

C# Code Example

```
using CrystalDecisions.CrystalReports.Engine;
using System.Data;
using MySql.Data.MySqlClient;

ReportDocument myReport = new ReportDocument();
DataSet myData = new DataSet();
MySql.Data.MySqlClient.MySqlConnection conn;
MySql.Data.MySqlClient.MySqlCommand cmd;
MySql.Data.MySqlClient.MySqlDataAdapter myAdapter;

conn = new MySql.Data.MySqlClient.MySqlConnection();
cmd = new MySql.Data.MySqlClient.MySqlCommand();
myAdapter = new MySql.Data.MySqlClient.MySqlDataAdapter();

conn.ConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test";

try
{
    cmd.CommandText = "SELECT city.name AS cityName, city.population AS CityPopulation, " +
        "country.name, country.population, country.continent " +
        "FROM country, city ORDER BY country.continent, country.name";
    cmd.Connection = conn;

    myAdapter.SelectCommand = cmd;
    myAdapter.Fill(myData);

    myReport.Load(@".\world_report.rpt");
    myReport.SetDataSource(myData);
    myViewer.ReportSource = myReport;
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show(ex.Message, "Report could not be created",
        MessageBoxButtons.OK, MessageBoxIcon.Error);
}
```

Visual Basic Code Example

```
Imports CrystalDecisions.CrystalReports.Engine
Imports System.Data
Imports MySql.Data.MySqlClient

Dim myReport As New ReportDocument
Dim myData As New DataSet
```

```
Dim conn As New MySqlConnection
Dim cmd As New MySqlCommand
Dim myAdapter As New MySqlDataAdapter

conn.ConnectionString = _
    "server=127.0.0.1;" _
    & "uid=root;" _
    & "pwd=12345;" _
    & "database=test"

Try
    conn.Open()

    cmd.CommandText = "SELECT city.name AS cityName, city.population AS CityPopulation, " _
        & "country.name, country.population, country.continent " _
        & "FROM country, city ORDER BY country.continent, country.name"
    cmd.Connection = conn

    myAdapter.SelectCommand = cmd
    myAdapter.Fill(myData)

    myReport.Load(".\world_report.rpt")
    myReport.SetDataSource(myData)
    myViewer.ReportSource = myReport
Catch ex As Exception
    MessageBox.Show(ex.Message, "Report could not be created", MessageBoxButtons.OK, MessageBoxIcon.Error)
End Try
```

A new data set it generated using the same query used to generate the previously saved data set. Once the data set is filled, a ReportDocument is used to load the report file and bind it to the data set. The ReportDocument is the passed as the ReportSource of the crViewer.

This same approach is taken when a report is created from a single table using Connector/ODBC. The data set replaces the table used in the report and the report is displayed properly.

When a report is created from multiple tables using Connector/ODBC, a data set with multiple tables must be created in our application. This enables each table in the report data source to be replaced with a report in the data set.

We populate a data set with multiple tables by providing multiple `SELECT` statements in our MySqlCommand object. These `SELECT` statements are based on the SQL query shown in Crystal Reports in the Database menu's Show SQL Query option. Assume the following query:

```
SELECT `country`.`Name`, `country`.`Continent`, `country`.`Population`, `city`.`Name`, `city`.`Population`
FROM `world`.`country` `country` LEFT OUTER JOIN `world`.`city` `city` ON `country`.`Code`=`city`.`CountryC
ORDER BY `country`.`Continent`, `country`.`Name`, `city`.`Name`
```

This query is converted to two `SELECT` queries and displayed with the following code:

C# Code Example

```
using CrystalDecisions.CrystalReports.Engine;
using System.Data;
using MySql.Data.MySqlClient;

ReportDocument myReport = new ReportDocument();
DataSet myData = new DataSet();
MySql.Data.MySqlClient.MySqlConnection conn;
MySql.Data.MySqlClient.MySqlCommand cmd;
MySql.Data.MySqlClient.MySqlDataAdapter myAdapter;

conn = new MySql.Data.MySqlClient.MySqlConnection();
cmd = new MySql.Data.MySqlClient.MySqlCommand();
myAdapter = new MySql.Data.MySqlClient.MySqlDataAdapter();
```

```
conn.ConnectionString = "server=127.0.0.1;uid=root;" +
    "pwd=12345;database=test";

try
{
    cmd.CommandText = "SELECT name, population, countrycode FROM city ORDER " +
        "BY countrycode, name; SELECT name, population, code, continent FROM " +
        "country ORDER BY continent, name";
    cmd.Connection = conn;

    myAdapter.SelectCommand = cmd;
    myAdapter.Fill(myData);

    myReport.Load(@".\world_report.rpt");
    myReport.Database.Tables(0).SetDataSource(myData.Tables(0));
    myReport.Database.Tables(1).SetDataSource(myData.Tables(1));
    myViewer.ReportSource = myReport;
}
catch (MySql.Data.MySqlClient.MySqlException ex)
{
    MessageBox.Show(ex.Message, "Report could not be created",
        MessageBoxButtons.OK, MessageBoxIcon.Error);
}
```

Visual Basic Code Example

```
Imports CrystalDecisions.CrystalReports.Engine
Imports System.Data
Imports MySql.Data.MySqlClient

Dim myReport As New ReportDocument
Dim myData As New DataSet
Dim conn As New MySqlConnection
Dim cmd As New MySqlCommand
Dim myAdapter As New MySqlDataAdapter

conn.ConnectionString = "server=127.0.0.1;" _
    & "uid=root;" _
    & "pwd=12345;" _
    & "database=world"

Try
    conn.Open()
    cmd.CommandText = "SELECT name, population, countrycode FROM city ORDER BY countrycode, name; " _
        & "SELECT name, population, code, continent FROM country ORDER BY continent, name"
    cmd.Connection = conn

    myAdapter.SelectCommand = cmd
    myAdapter.Fill(myData)

    myReport.Load(".\world_report.rpt")
    myReport.Database.Tables(0).SetDataSource(myData.Tables(0))
    myReport.Database.Tables(1).SetDataSource(myData.Tables(1))
    myViewer.ReportSource = myReport
Catch ex As Exception
    MessageBox.Show(ex.Message, "Report could not be created", MessageBoxButtons.OK, MessageBoxIcon.Error)
End Try
```

It is important to order the SELECT queries in alphabetic order, as this is the order the report will expect its source tables to be in. One SetDataSource statement is needed for each table in the report.

This approach can cause performance problems because Crystal Reports must bind the tables together on the client-side, which will be slower than using a pre-saved data set.

5.14 Asynchronous Methods

The Task-based Asynchronous Pattern (TAP) is a pattern for asynchrony in the .NET Framework. It is based on the `Task` and `Task<TResult>` types in the `System.Threading.Tasks` namespace, which are used to represent arbitrary asynchronous operations.

Async-Await are new keywords introduced to work with the TAP. The **Async modifier** is used to specify that a method, lambda expression, or anonymous method is asynchronous. The **Await** operator is applied to a task in an asynchronous method to suspend the execution of the method until the awaited task completes.

Requirements

- **Async-Await** support requires .NET Framework 4.5 or later
- **TAP** support requires .NET Framework 4.0 or later
- MySQL Connector/NET 6.9 or later

Methods

The following methods can be used with either TAP or Async-Await.

- Namespace `MySql.Data.Entity`
  - Class `EFMySqlCommand`
    - `Task PrepareAsync()`
    - `Task PrepareAsync(CancellationToken)`
- Namespace `MySql.Data`
  - Class `MySqlBulkLoader`
    - `Task<int> LoadAsync()`
    - `Task<int> LoadAsync(CancellationToken`
  - Class `MySqlConnection`
    - `Task<MySqlTransaction> BeginTransactionAsync()`
    - `Task<MySqlTransaction> BeginTransactionAsync (CancellationToken)`
    - `Task<MySqlTransaction> BeginTransactionAsync(IsolationLevel)`
    - `Task<MySqlTransaction> BeginTransactionAsync (IsolationLevel , CancellationToken)`
    - `Task ChangeDatabaseAsync(string)`
    - `Task ChangeDatabaseAsync(string, CancellationToken)`
    - `Task CloseAsync()`
    - `Task CloseAsync(CancellationToken)`
    - `Task ClearPoolAsync(MySqlConnection)`
    - `Task ClearPoolAsync(MySqlConnection, CancellationToken)`

- `Task ClearAllPoolsAsync()`
- `Task ClearAllPoolsAsync(CancellationToken)`
- `Task<MySqlSchemaCollection> GetSchemaCollection(string, string[])`
- `Task<MySqlSchemaCollection> GetSchemaCollection(string, string[], CancellationToken)`

- Class `MySqlDataAdapter`
  - `Task<int> FillAsync(DataSet)`
  - `Task<int> FillAsync(DataSet, CancellationToken)`
  - `Task<int> FillAsync(DataTable)`
  - `Task<int> FillAsync(DataTable, CancellationToken)`
  - `Task<int> FillAsync(DataSet, string)`
  - `Task<int> FillAsync(DataSet, string, CancellationToken)`
  - `Task<int> FillAsync(DataTable, IDataReader)`
  - `Task<int> FillAsync(DataTable, IDataReader, CancellationToken)`
  - `Task<int> FillAsync(DataTable, IDbCommand, CommandBehavior)`
  - `Task<int> FillAsync(DataTable, IDbCommand, CommandBehavior, CancellationToken)`
  - `Task<int> FillAsync(int, int, params DataTable[])`
  - `Task<int> FillAsync(int, int, params DataTable[], CancellationToken)`
  - `Task<int> FillAsync(DataSet, int, int, string)`
  - `Task<int> FillAsync(DataSet, int, int, string, CancellationToken)`
  - `Task<int> FillAsync(DataSet, string, IDataReader, int, int)`
  - `Task<int> FillAsync(DataSet, string, IDataReader, int, int, CancellationToken)`
  - `Task<int> FillAsync(DataTable[], int, int, IDbCommand, CommandBehavior)`
  - `Task<int> FillAsync(DataTable[], int, int, IDbCommand, CommandBehavior, CancellationToken)`
  - `Task<int> FillAsync(DataSet, int, int, string, IDbCommand, CommandBehavior)`
  - `Task<int> FillAsync(DataSet, int, int, string, IDbCommand, CommandBehavior, CancellationToken)`
  - `Task<DataTable[]> FillSchemaAsync(DataSet, SchemaType)`

- `Task<DataTable[]> FillSchemaAsync(DataSet, SchemaType, CancellationToken)`
- `Task<DataTable[]> FillSchemaAsync(DataSet, SchemaType, string)`
- `Task<DataTable[]> FillSchemaAsync(DataSet, SchemaType, string, CancellationToken)`
- `Task<DataTable[]> FillSchemaAsync(DataSet, SchemaType, string, IDataReader)`
- `Task<DataTable[]> FillSchemaAsync(DataSet, SchemaType, string, IDataReader, CancellationToken)`
- `Task<DataTable[]> FillSchemaAsync(DataSet, SchemaType, IDbCommand, string, CommandBehavior)`
- `Task<DataTable[]> FillSchemaAsync(DataSet, SchemaType, IDbCommand, string, CommandBehavior, CancellationToken)`
- `Task<DataTable> FillSchemaAsync(DataTable, SchemaType)`
- `Task<DataTable> FillSchemaAsync(DataTable, SchemaType, CancellationToken)`
- `Task<DataTable> FillSchemaAsync(DataTable, SchemaType, IDataReader)`
- `Task<DataTable> FillSchemaAsync(DataTable, SchemaType, IDataReader, CancellationToken)`
- `Task<DataTable> FillSchemaAsync(DataTable, SchemaType, IDbCommand, CommandBehavior)`
- `Task<DataTable> FillSchemaAsync(DataTable, SchemaType, IDbCommand, CommandBehavior, CancellationToken)`
- `Task<int> UpdateAsync(DataRow[])`
- `Task<int> UpdateAsync(DataRow[], CancellationToken)`
- `Task<int> UpdateAsync(DataSet)`
- `Task<int> UpdateAsync(DataSet, CancellationToken)`
- `Task<int> UpdateAsync(DataTable)`
- `Task<int> UpdateAsync(DataTable, CancellationToken)`
- `Task<int> UpdateAsync(DataRow[], DataTableMapping, CancellationToken)`
- `Task<int> UpdateAsync(DataSet, string)`
- `Task<int> UpdateAsync(DataSet, string, CancellationToken)`

- Class `MySqlHelper`
  - `Task<DataRow> ExecuteDataRowAsync(string, string, params MySqlParameter[])`

- `Task<DataRow> ExecuteDataRowAsync(string, string, CancellationToken, params MySqlParameter[])`
- `Task<int> ExecuteNonQueryAsync(MySqlConnection, string, params MySqlParameter[])`
- `Task<int> ExecuteNonQueryAsync(MySqlConnection, string, CancellationToken, params MySqlParameter[])`
- `Task<int> ExecuteNonQueryAsync(string, string, params MySqlParameter[])`
- `Task<int> ExecuteNonQueryAsync(string, string, CancellationToken, params MySqlParameter[])`
- `Task<DataSet> ExecuteDatasetAsync(string, string)`
- `Task<DataSet> ExecuteDatasetAsync(string, string, CancellationToken)`
- `Task<DataSet> ExecuteDatasetAsync(string, string, CancellationToken, params MySqlParameter[])`
- `Task<DataSet> ExecuteDatasetAsync(MySqlConnection, string)`
- `Task<DataSet> ExecuteDatasetAsync(MySqlConnection, string, CancellationToken)`
- `Task<DataSet> ExecuteDatasetAsync(MySqlConnection, string, params MySqlParameter[])`
- `Task<DataSet> ExecuteDatasetAsync(MySqlConnection, string, CancellationToken, params MySqlParameter[])`
- `Task UpdateDataSetAsync(string, string, DataSet, string)`
- `Task UpdateDataSetAsync(string, string, DataSet, string, CancellationToken)`
- `Task<MySqlDataReader> ExecuteReaderAsync(MySqlConnection, MySqlTransaction, string, MySqlParameter[], bool)`
- `Task<MySqlDataReader> ExecuteReaderAsync(MySqlConnection, MySqlTransaction, string, MySqlParameter[], bool, CancellationToken)`
- `Task<MySqlDataReader> ExecuteReaderAsync(string, string)`
- `Task<MySqlDataReader> ExecuteReaderAsync(string, string, CancellationToken)`
- `Task<MySqlDataReader> ExecuteReaderAsync(MySqlConnection, string)`
- `Task<MySqlDataReader> ExecuteReaderAsync(MySqlConnection, string, CancellationToken)`
- `Task<MySqlDataReader> ExecuteReaderAsync(string, string, params MySqlParameter[])`

- `Task<MySqlDataReader> ExecuteReaderAsync(string, string, CancellationToken, params MySqlParameter[])`
- `Task<MySqlDataReader> ExecuteReaderAsync(MySqlConnection, string, params MySqlParameter[])`
- `Task<MySqlDataReader> ExecuteReaderAsync(MySqlConnection, string, CancellationToken, params MySqlParameter[])`
- `Task<object> ExecuteScalarAsync(string, string)`
- `Task<object> ExecuteScalarAsync(string, string, CancellationToken)`
- `Task<object> ExecuteScalarAsync(string, string, params MySqlParameter[])`
- `Task<object> ExecuteScalarAsync(string, string, CancellationToken, params MySqlParameter[])`
- `Task<object> ExecuteScalarAsync(MySqlConnection, string)`
- `Task<object> ExecuteScalarAsync(MySqlConnection, string, CancellationToken)`
- `Task<object> ExecuteScalarAsync(MySqlConnection, string, params MySqlParameter[])`
- `Task<object> ExecuteScalarAsync(MySqlConnection, string, CancellationToken, params MySqlParameter[])`

- Class `MySqlScript`
  - `Task<int> ExecuteAsync()`
  - `Task<int> ExecuteAsync(CancellationToken)`

In addition to the methods listed above, the following are methods inherited from the .NET Framework:

- Namespace `MySql.Data.Entity`
  - Class `EFMySqlCommand`
    - `Task<DbDataReader> ExecuteDbDataReaderAsync(CommandBehaviour, CancellationToken)`
    - `Task<int> ExecuteNonQueryAsync()`
    - `Task<int> ExecuteNonQueryAsync(CancellationToken)`
    - `Task<DbDataReader> ExecuteReaderAsync()`
    - `Task<DbDataReader> ExecuteReaderAsync(CancellationToken)`
    - `Task<DbDataReader> ExecuteReaderAsync(CommandBehaviour)`
    - `Task<DbDataReader> ExecuteReaderAsync(CommandBehaviour, CancellationToken)`
    - `Task<object> ExecuteScalarAsync()`

        - `Task<object> ExecuteScalarAsync(CancellationToken)`
    - Namespace `MySql.Data`
        - Class `MySqlCommand`
            - `Task<DbDataReader> ExecuteDbDataReaderAsync(CommandBehaviour, CancellationToken)`
            - `Task<int> ExecuteNonQueryAsync()`
            - `Task<int> ExecuteNonQueryAsync(CancellationToken)`
            - `Task<DbDataReader> ExecuteReaderAsync()`
            - `Task<DbDataReader> ExecuteReaderAsync(CancellationToken)`
            - `Task<DbDataReader> ExecuteReaderAsync(CommandBehaviour)`
            - `Task<DbDataReader> ExecuteReaderAsync(CommandBehaviour, CancellationToken)`
            - `Task<object> ExecuteScalarAsync()`
            - `Task<object> ExecuteScalarAsync(CancellationToken)`
        - Class `MySqlConnection`
            - `Task OpenAsync()`
            - `Task OpenAsync(CancellationToken)`
        - Class `MySqlDataReader`
            - `Task<T> GetFieldValueAsync<T>(int)`
            - `Task<T> GetFieldValueAsync<T>(int, CancellationToken)`
            - `Task<bool> IsDBNullAsync(int)`
            - `Task<bool> IsDBNullAsync(int, CancellationToken)`
            - `Task<bool> NextResultAsync()`
            - `Task<bool> NextResultAsync(CancellationToken)`
            - `Task<bool> ReadAsync()`
            - `Task<bool> ReadAsync(CancellationToken)`

Examples

The following C# code examples demonstrate how to use the asynchronous methods:

In this example, a method has the `async` modifier because the method `await` call made applies to the method `LoadAsync`. The method returns a `Task` object that contains information about the result of the awaited method. Returning `Task` is like having a void method, but you should not use `async void` if your method is not a top-level access method like an event.

```
public async Task BulkLoadAsync()
{
  MySqlConnection myConn = new MySqlConnection("MyConnectionString");
  MySqlBulkLoader loader = new MySqlBulkLoader(myConn);

  loader.TableName       = "BulkLoadTest";
  loader.FileName        = @"c:\MyPath\MyFile.txt";
  loader.Timeout         = 0;

  var result             = await loader.LoadAsync();
}
```

In this example, an "async void" method is used with "await" for the `ExecuteNonQueryAsync` method, to correspond to the onclick event of a button. This is why the method does not return a `Task`.

```
private async void myButton_Click()
{
  MySqlConnection myConn = new MySqlConnection("MyConnectionString");
  MySqlCommand proc      = new MySqlCommand("MyAsyncSpTest", myConn);

  proc.CommandType       = CommandType.StoredProcedure;

  int result             = await proc.ExecuteNonQueryAsync();
}
```

5.15 Binary and Nonbinary Issues

There are certain situations where MySQL will return incorrect metadata about one or more columns. More specifically, the server can sometimes report that a column is binary when it is not (and the reverse). In these situations, it becomes practically impossible for the connector to be able to correctly identify the correct metadata.

Some examples of situations that may return incorrect metadata are:

- Execution of `SHOW PROCESSLIST`. Some of the columns are returned as binary even though they only hold string data.
- When a temporary table is used to process a result set, some columns may be returned with incorrect binary flags.
- Some server functions such `DATE_FORMAT` return the column incorrectly as binary.

With the availability of `BINARY` and `VARBINARY` data types, it is important to respect the metadata returned by the server. However, some existing applications may encounter issues with this change and can use a connection string option to enable or disable it. By default, Connector/NET respects the binary flags returned by the server. You might need to make small changes to your application to accommodate this change.

In the event that the changes required to your application are too large, adding `'respect binary flags=false'` to your connection string causes the connector to use the prior behavior: any column that is marked as string, regardless of binary flags, will be returned as string. Only columns that are specifically marked as a `BLOB` will be returned as `BLOB`.

5.16 Character Set Considerations for Connector/NET

Treating Binary Blobs As UTF8

Before the introduction of 4-byte UTF-8 character set, MySQL did not support 4-byte UTF8 sequences. This makes it difficult to represent some multibyte languages such as Japanese. To try and alleviate this, MySQL Connector/NET supports a mode where binary blobs can be treated as strings.

To do this, you set the `'Treat Blobs As UTF8'` connection string keyword to `true`. This is all that needs to be done to enable conversion of all binary blobs to UTF8 strings. To convert only some of your BLOB columns, you can make use of the `'BlobAsUTF8IncludePattern'` and `'BlobAsUTF8ExcludePattern'` keywords. Set these to a regular expression pattern that matches the column names to include or exclude respectively.

When the regular expression patterns both match a single column, the include pattern is applied before the exclude pattern. The result, in this case, is that the column is excluded. Also, be aware that this mode does not apply to columns of type `BINARY` or `VARBINARY` and also do not apply to nonbinary `BLOB` columns.

This mode only applies to reading strings out of MySQL. To insert 4-byte UTF8 strings into blob columns, use the .NET `Encoding.GetBytes` function to convert your string to a series of bytes. You can then set this byte array as a parameter for a `BLOB` column.

Chapter 6 Connector/NET Tutorials

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The following MySQL Connector/NET tutorials illustrate how to develop MySQL programs using technologies such as Visual Studio, C#, ASP.NET, and the .NET, .NET Core, and Mono frameworks. Work through the first tutorial to verify that you have the right software components installed and configured, then choose other tutorials to try depending on the features you intend to use in your applications.

6.1 Tutorial: An Introduction to Connector/NET Programming

This section provides a gentle introduction to programming with MySQL Connector/NET. The code example is written in C#, and is designed to work on both Microsoft .NET Framework and Mono.

This tutorial is designed to get you up and running with Connector/NET as quickly as possible, it does not go into detail on any particular topic. However, the following sections of this manual describe each of the topics introduced in this tutorial in more detail. In this tutorial you are encouraged to type in and run the code, modifying it as required for your setup.

This tutorial assumes you have MySQL and Connector/NET already installed. It also assumes that you have installed the `world` database sample, which can be downloaded from the MySQL Documentation page. You can also find details on how to install the database on the same page.

> **Note**
>
> Before compiling the code example, make sure that you have added References to your project as required. The References required are `System`, `System.Data` and `MySql.Data`.

6.1.1 The MySqlConnection Object

For your MySQL Connector/NET application to connect to a MySQL database, it must establish a connection by using a `MySqlConnection` object.

The `MySqlConnection` constructor takes a connection string as one of its parameters. The connection string provides necessary information to make the connection to the MySQL database. The connection string is discussed more fully in Chapter 4, *Connector/NET Connections*. For a list of supported connection string options, see Section 4.5, “Connector/NET Connection Options Reference”.

The following code shows how to create a connection object/

```
using System;
using System.Data;

using MySql.Data;
using MySql.Data.MySqlClient;

public class Tutorial1
{
    public static void Main()
    {
        string connStr = "server=localhost;user=root;database=world;port=3306;password=******";
        MySqlConnection conn = new MySqlConnection(connStr);
        try
        {
            Console.WriteLine("Connecting to MySQL...");
            conn.Open();
            // Perform database operations
        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.ToString());
        }
        conn.Close();
        Console.WriteLine("Done.");
    }
}
```

When the `MySqlConnection` constructor is invoked, it returns a connection object, which is used for subsequent database operations. Open the connection before any other operations take place. Before the application exits, close the connection to the database by calling `Close` on the connection object.

Sometimes an attempt to perform an `Open` on a connection object can fail, generating an exception that can be handled using standard exception handling code.

In this section you have learned how to create a connection to a MySQL database, and open and close the corresponding connection object.

6.1.2 The MySqlCommand Object

When a connection has been established with the MySQL database, the next step enables you to perform database operations. This task can be achieved through the use of the `MySqlCommand` object.

After it has been created, there are three main methods of interest that you can call:

- `ExecuteReader` to query the database. Results are usually returned in a `MySqlDataReader` object, created by `ExecuteReader`.
- `ExecuteNonQuery` to insert, update, and delete data.
- `ExecuteScalar` to return a single value.

After the `MySqlCommand` object is created, you can call one of the previous methods on it to carry out a database operation, such as perform a query. The results are usually returned into a `MySqlDataReader`

object, and then processed. For example, the results might be displayed as the following code example demonstrates.

```
using System;
using System.Data;

using MySql.Data;
using MySql.Data.MySqlClient;

public class Tutorial2
{
    public static void Main()
    {
        string connStr = "server=localhost;user=root;database=world;port=3306;password=******";
        MySqlConnection conn = new MySqlConnection(connStr);
        try
        {
            Console.WriteLine("Connecting to MySQL...");
            conn.Open();

            string sql = "SELECT Name, HeadOfState FROM Country WHERE Continent='Oceania'";
            MySqlCommand cmd = new MySqlCommand(sql, conn);
            MySqlDataReader rdr = cmd.ExecuteReader();

            while (rdr.Read())
            {
                Console.WriteLine(rdr[0]+" -- "+rdr[1]);
            }
            rdr.Close();
        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.ToString());
        }

        conn.Close();
        Console.WriteLine("Done.");
    }
}
```

When a connection has been created and opened, the code then creates a `MySqlCommand` object. Then the SQL query to be executed is passed to the `MySqlCommand` constructor. The `ExecuteReader` method is then used to generate a `MySqlReader` object. The `MySqlReader` object contains the results generated by the SQL executed on the `MySqlCommand` object. When the results have been obtained in a `MySqlReader` object, the results can be processed. In this case, the information is printed out by a `while` loop. Finally, the `MySqlReader` object is disposed of by invoking the `Close` method.

The next example shows how to use the `ExecuteNonQuery` method.

The procedure for performing an `ExecuteNonQuery` method call is simpler, as there is no need to create an object to store results. This is because `ExecuteNonQuery` is only used for inserting, updating and deleting data. The following example illustrates a simple update to the `Country` table:

```
using System;
using System.Data;

using MySql.Data;
using MySql.Data.MySqlClient;

public class Tutorial3
{
    public static void Main()
    {
        string connStr = "server=localhost;user=root;database=world;port=3306;password=******";
        MySqlConnection conn = new MySqlConnection(connStr);
```

```
        try
        {
            Console.WriteLine("Connecting to MySQL...");
            conn.Open();

            string sql = "INSERT INTO Country (Name, HeadOfState, Continent) VALUES ('Disneyland','Mickey Mous
            MySqlCommand cmd = new MySqlCommand(sql, conn);
            cmd.ExecuteNonQuery();
        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.ToString());
        }

        conn.Close();
        Console.WriteLine("Done.");
    }
}
```

The query is constructed, the `MySqlCommand` object created and the `ExecuteNonQuery` method called on the `MySqlCommand` object. You can access your MySQL database with `mysql` and verify that the update was carried out correctly.

Finally, you can use the `ExecuteScalar` method to return a single value. Again, this is straightforward, as a `MySqlDataReader` object is not required to store results, a variable is used instead. The following code illustrates how to use the `ExecuteScalar` method:

```
using System;
using System.Data;

using MySql.Data;
using MySql.Data.MySqlClient;

public class Tutorial4
{
    public static void Main()
    {
        string connStr = "server=localhost;user=root;database=world;port=3306;password=******";
        MySqlConnection conn = new MySqlConnection(connStr);
        try
        {
            Console.WriteLine("Connecting to MySQL...");
            conn.Open();

            string sql = "SELECT COUNT(*) FROM Country";
            MySqlCommand cmd = new MySqlCommand(sql, conn);
            object result = cmd.ExecuteScalar();
            if (result != null)
            {
                int r = Convert.ToInt32(result);
                Console.WriteLine("Number of countries in the world database is: " + r);
            }

        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.ToString());
        }

        conn.Close();
        Console.WriteLine("Done.");
    }
}
```

This example uses a simple query to count the rows in the `Country` table. The result is obtained by calling `ExecuteScalar` on the `MySqlCommand` object.

6.1.3 Working with Decoupled Data

Previously, when using `MySqlDataReader`, the connection to the database was continually maintained unless explicitly closed. It is also possible to work in a manner where a connection is only established when needed. For example, in this mode, a connection could be established to read a chunk of data, the data could then be modified by the application as required. A connection could then be reestablished only if and when the application writes data back to the database. This decouples the working data set from the database.

This decoupled mode of working with data is supported by MySQL Connector/NET. There are several parts involved in allowing this method to work:

- **Data Set.** The Data Set is the area in which data is loaded to read or modify it. A `DataSet` object is instantiated, which can store multiple tables of data.
- **Data Adapter.** The Data Adapter is the interface between the Data Set and the database itself. The Data Adapter is responsible for efficiently managing connections to the database, opening and closing them as required. The Data Adapter is created by instantiating an object of the `MySqlDataAdapter` class. The `MySqlDataAdapter` object has two main methods: `Fill` which reads data into the Data Set, and `Update`, which writes data from the Data Set to the database.
- **Command Builder.** The Command Builder is a support object. The Command Builder works in conjunction with the Data Adapter. When a `MySqlDataAdapter` object is created, it is typically given an initial SELECT statement. From this `SELECT` statement the Command Builder can work out the corresponding `INSERT`, `UPDATE` and `DELETE` statements that would be required to update the database. To create the Command Builder, an object of the class `MySqlCommandBuilder` is created.

The remaining sections describe each of these classes in more detail.

Instantiating a DataSet Object

A `DataSet` object can be created simply, as shown in the following code-snippet:

```
DataSet dsCountry;
...
dsCountry = new DataSet();
```

Although this creates the `DataSet` object, it has not yet filled it with data. For that, a Data Adapter is required.

Instantiating a MySqlDataAdapter Object

The `MySqlDataAdapter` can be created as illustrated by the following example:

```
MySqlDataAdapter daCountry;
...
string sql = "SELECT Code, Name, HeadOfState FROM Country WHERE Continent='North America'";
daCountry = new MySqlDataAdapter (sql, conn);
```

> **Note**
>
> The `MySqlDataAdapter` is given the SQL specifying the data to work with.

Instantiating a MySqlCommandBuilder Object

Once the `MySqlDataAdapter` has been created, it is necessary to generate the additional statements required for inserting, updating and deleting data. There are several ways to do this, but in this tutorial

you will see how this can most easily be done with `MySqlCommandBuilder`. The following code snippet illustrates how this is done:

```
MySqlCommandBuilder cb = new MySqlCommandBuilder(daCountry);
```

> **Note**
>
> The `MySqlDataAdapter` object is passed as a parameter to the command builder.

Filling the Data Set

To do anything useful with the data from your database, you need to load it into a Data Set. This is one of the jobs of the `MySqlDataAdapter` object, and is carried out with its `Fill` method. The following code example illustrates this point.

```
DataSet dsCountry;
...
dsCountry = new DataSet();
...
daCountry.Fill(dsCountry, "Country");
```

The `Fill` method is a `MySqlDataAdapter` method, and the Data Adapter knows how to establish a connection with the database and retrieve the required data, and then populate the Data Set when the `Fill` method is called. The second parameter “Country” is the table in the Data Set to update.

Updating the Data Set

The data in the Data Set can now be manipulated by the application as required. At some point, changes to data will need to be written back to the database. This is achieved through a `MySqlDataAdapter` method, the `Update` method.

```
daCountry.Update(dsCountry, "Country");
```

Again, the Data Set and the table within the Data Set to update are specified.

Working Example

The interactions between the `DataSet`, `MySqlDataAdapter` and `MySqlCommandBuilder` classes can be a little confusing, so their operation can perhaps be best illustrated by working code.

In this example, data from the `world` database is read into a Data Grid View control. Here, the data can be viewed and changed before clicking an update button. The update button then activates code to write changes back to the database. The code uses the principles explained previously. The application was built using the Microsoft Visual Studio to place and create the user interface controls, but the main code that uses the key classes described previously is shown in the next code example, and is portable.

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;

using MySql.Data;
using MySql.Data.MySqlClient;
```

```
namespace WindowsFormsApplication5
{
    public partial class Form1 : Form
    {
        MySqlDataAdapter daCountry;
        DataSet dsCountry;

        public Form1()
        {
            InitializeComponent();
        }

        private void Form1_Load(object sender, EventArgs e)
        {

            string connStr = "server=localhost;user=root;database=world;port=3306;password=******";
            MySqlConnection conn = new MySqlConnection(connStr);
            try
            {
                label2.Text = "Connecting to MySQL...";

                string sql = "SELECT Code, Name, HeadOfState FROM Country WHERE Continent='North America'"
                daCountry = new MySqlDataAdapter (sql, conn);
                MySqlCommandBuilder cb = new MySqlCommandBuilder(daCountry);

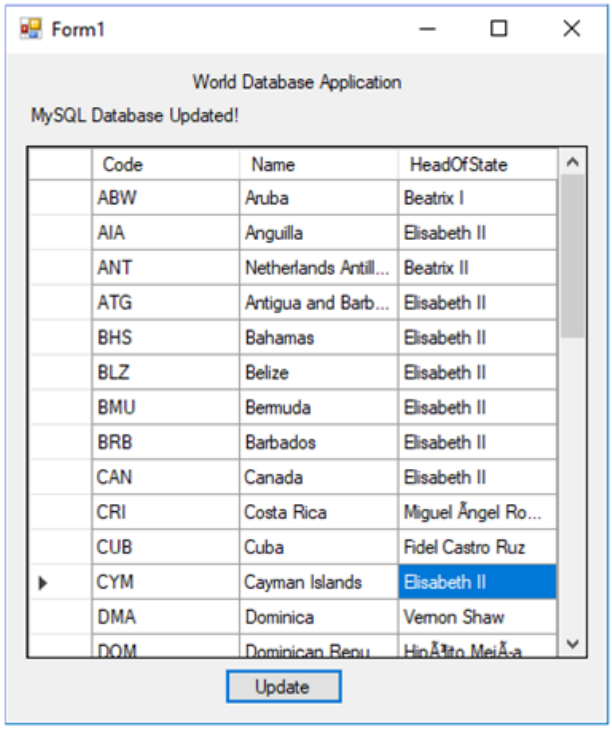
                dsCountry = new DataSet();
                daCountry.Fill(dsCountry, "Country");
                dataGridView1.DataSource = dsCountry;
                dataGridView1.DataMember = "Country";
            }
            catch (Exception ex)
            {
                label2.Text = ex.ToString();
            }
        }

        private void button1_Click(object sender, EventArgs e)
        {
            daCountry.Update(dsCountry, "Country");
            label2.Text = "MySQL Database Updated!";
        }

    }
}
```

The following figure shows the application started. The World Database Application updated data in three columns: Code, Name, and HeadOfState.

Figure 6.1 World Database Application



6.1.4 Working with Parameters

This part of the tutorial shows you how to use parameters in your MySQL Connector/NET application.

Although it is possible to build SQL query strings directly from user input, this is not advisable as it does not prevent erroneous or malicious information being entered. It is safer to use parameters as they will be processed as field data only. For example, imagine the following query was constructed from user input:

```
string sql = "SELECT Name, HeadOfState FROM Country WHERE Continent = "+user_continent;
```

If the string `user_continent` came from a Text Box control, there would potentially be no control over the string entered by the user. The user could enter a string that generates a runtime error, or in the worst case actually harms the system. When using parameters it is not possible to do this because a parameter is only ever treated as a field parameter, rather than an arbitrary piece of SQL code.

The same query written using a parameter for user input is:

```
string sql = "SELECT Name, HeadOfState FROM Country WHERE Continent = @Continent";
```

> **Note**
>
> The parameter is preceded by an '@' symbol to indicate it is to be treated as a parameter.

As well as marking the position of the parameter in the query string, it is necessary to add a parameter to the `MySqlCommand` object. This is illustrated by the following code snippet:

```
cmd.Parameters.AddWithValue("@Continent", "North America");
```

In this example the string "North America" is supplied as the parameter value statically, but in a more practical example it would come from a user input control.

A further example illustrates the complete process:

```
using System;
using System.Data;

using MySql.Data;
using MySql.Data.MySqlClient;

public class Tutorial5
{
    public static void Main()
    {
        string connStr = "server=localhost;user=root;database=world;port=3306;password=******";
        MySqlConnection conn = new MySqlConnection(connStr);
        try
        {
            Console.WriteLine("Connecting to MySQL...");
            conn.Open();

            string sql = "SELECT Name, HeadOfState FROM Country WHERE Continent=@Continent";
            MySqlCommand cmd = new MySqlCommand(sql, conn);

            Console.WriteLine("Enter a continent e.g. 'North America', 'Europe': ");
            string user_input = Console.ReadLine();

            cmd.Parameters.AddWithValue("@Continent", user_input);

            MySqlDataReader rdr = cmd.ExecuteReader();

            while (rdr.Read())
            {
                Console.WriteLine(rdr["Name"]+" --- "+rdr["HeadOfState"]);
            }
            rdr.Close();
        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.ToString());
        }

        conn.Close();
        Console.WriteLine("Done.");
    }
}
```

In this part of the tutorial you have see how to use parameters to make your code more secure.

6.1.5 Working with Stored Procedures

This section illustrates how to work with stored procedures. Putting database-intensive operations into stored procedures lets you define an API for your database application. You can reuse this API across multiple applications and multiple programming languages. This technique avoids duplicating database code, saving time and effort when you make updates due to schema changes, tune the performance of queries, or add new database operations for logging, security, and so on. Before working through this tutorial, familiarize yourself with the `CREATE PROCEDURE` and `CREATE FUNCTION` statements that create different kinds of stored routines.

For the purposes of this tutorial, you will create a simple stored procedure to see how it can be called from MySQL Connector/NET. In the MySQL Client program, connect to the `world` database and enter the following stored procedure:

```
DELIMITER //
CREATE PROCEDURE country_hos
(IN con CHAR(20))
```

```
BEGIN
  SELECT Name, HeadOfState FROM Country
  WHERE Continent = con;
END //
DELIMITER ;
```

Test that the stored procedure works as expected by typing the following into the `mysql` command interpreter:

```
CALL country_hos('Europe');
```

> **Note**
>
> The stored routine takes a single parameter, which is the continent to restrict your search to.

Having confirmed that the stored procedure is present and correct, you can see how to access it from Connector/NET.

Calling a stored procedure from your Connector/NET application is similar to techniques you have seen earlier in this tutorial. A `MySqlCommand` object is created, but rather than taking an SQL query as a parameter, it takes the name of the stored procedure to call. Set the `MySqlCommand` object to the type of stored procedure, as shown by the following code snippet:

```
string rtn = "country_hos";
MySqlCommand cmd = new MySqlCommand(rtn, conn);
cmd.CommandType = CommandType.StoredProcedure;
```

In this case, the stored procedure requires you to pass a parameter. This can be achieved using the techniques seen in the previous section on parameters, Section 6.1.4, “Working with Parameters”, as shown in the following code snippet:

```
cmd.Parameters.AddWithValue("@con", "Europe");
```

The value of the parameter `@con` could more realistically have come from a user input control, but for simplicity it is set as a static string in this example.

At this point, everything is set up and you can call the routine using techniques also learned in earlier sections. In this case, the `ExecuteReader` method of the `MySqlCommand` object is used.

The following code shows the complete stored procedure example.

```
using System;
using System.Data;

using MySql.Data;
using MySql.Data.MySqlClient;

public class Tutorial6
{
    public static void Main()
    {
        string connStr = "server=localhost;user=root;database=world;port=3306;password=******";
        MySqlConnection conn = new MySqlConnection(connStr);
        try
        {
            Console.WriteLine("Connecting to MySQL...");
            conn.Open();

            string rtn = "country_hos";
            MySqlCommand cmd = new MySqlCommand(rtn, conn);
            cmd.CommandType = CommandType.StoredProcedure;
```

```
            cmd.Parameters.AddWithValue("@con", "Europe");

            MySqlDataReader rdr = cmd.ExecuteReader();
            while (rdr.Read())
            {
                Console.WriteLine(rdr[0] + " --- " + rdr[1]);
            }
            rdr.Close();
        }
        catch (Exception ex)
        {
            Console.WriteLine(ex.ToString());
        }

        conn.Close();
        Console.WriteLine("Done.");
    }
}
```

In this section, you have seen how to call a stored procedure from Connector/NET. For the moment, this concludes our introductory tutorial on programming with Connector/NET.

6.2 ASP.NET Provider Model and Tutorials

MySQL Connector/NET includes a provider model for use with ASP.NET applications. This model enables developers to focus on the business logic of their application instead of having to recreate such boilerplate items as membership and roles support.

Connector/NET supports the following web providers:

- Membership provider
- Roles provider
- Profiles provider
- Session state provider

The following tables show the supported providers, their default provider and the corresponding MySQL provider.

Membership Provider

Default Provider	`System.Web.Security.SqlMembershipProvider`
MySQL Provider	`MySql.Web.Security.MySQLMembershipProvider`

Role Provider

Default Provider	`System.Web.Security.SqlRoleProvider`
MySQL Provider	`MySql.Web.Security.MySQLRoleProvider`

Profile Provider

Default Provider	`System.Web.Profile.SqlProfileProvider`

MySQL Provider	`MySql.Web.Profile.MySQLProfileProvider`

Session State Provider

Default Provider	`System.Web.SessionState.InProcSessionStateStore`
MySQL Provider	`MySql.Web.SessionState.MySqlSessionStateStore`

> **Note**
>
> The MySQL session state provider uses slightly different capitalization on the class name compared to the other MySQL providers.

Installing the Providers

The installation of Connector/NET installs the providers and registers them in the .NET configuration file (`machine.config`) on your computer. The additional entries modify the `system.web` section of the file, which appears similar to the following example after the installation.

```
<system.web>
  <processModel autoConfig="true" />
  <httpHandlers />
  <membership>
    <providers>
      <add name="AspNetSqlMembershipProvider" type="System.Web.Security.SqlMembershipProvider, System.Web, Ver
      <add name="MySQLMembershipProvider" type="MySql.Web.Security.MySQLMembershipProvider, MySql.Web, Version
    </providers>
  </membership>
  <profile>
    <providers>
      <add name="AspNetSqlProfileProvider" connectionStringName="LocalSqlServer" applicationName="/" type="Sys
      <add name="MySQLProfileProvider" type="MySql.Web.Profile.MySQLProfileProvider, MySql.Web, Version=6.1.1.
    </providers>
  </profile>
  <roleManager>
    <providers>
      <add name="AspNetSqlRoleProvider" connectionStringName="LocalSqlServer" applicationName="/" type="System
      <add name="AspNetWindowsTokenRoleProvider" applicationName="/" type="System.Web.Security.WindowsTokenRol
      <add name="MySQLRoleProvider" type="MySql.Web.Security.MySQLRoleProvider, MySql.Web, Version=6.1.1.0, Cu
    </providers>
  </roleManager>
</system.web>
```

Each provider type can have multiple provider implementations. The default provider can also be set here using the `defaultProvider` attribute, but usually this is set in the `web.config` file either manually or by using the ASP.NET configuration tool.

At time of writing, the `MySqlSessionStateStore` is not added to `machine.config` at install time, and so add the following:

```
<sessionState>
  <providers>
    <add name="MySqlSessionStateStore" type="MySql.Web.SessionState.MySqlSessionStateStore, MySql.Web, Version
  </providers>
</sessionState>
```

The session state provider uses the `customProvider` attribute, rather than `defaultProvider`, to set the provider as the default. A typical `web.config` file might contain:

```
   <system.web>
```

```
        <membership defaultProvider="MySQLMembershipProvider" />
        <roleManager defaultProvider="MySQLRoleProvider" />
        <profile defaultProvider="MySQLProfileProvider" />
        <sessionState customProvider="MySqlSessionStateStore" />
        <compilation debug="false">
          ...
```

This sets the MySQL Providers as the defaults to be used in this web application.

The providers are implemented in the file `mysql.web.dll` and this file can be found in your Connector/NET installation folder. There is no need to run any type of SQL script to set up the database schema, as the providers create and maintain the proper schema automatically.

Working with MySQL Providers

The easiest way to start using the providers is to use the ASP.NET configuration tool that is available on the Solution Explorer toolbar when you have a website project loaded.

In the web pages that open, you can select the MySQL membership and roles providers by picking a custom provider for each area.

When the provider is installed, it creates a dummy connection string named `LocalMySqlServer`. Although this has to be done so that the provider will work in the ASP.NET configuration tool, you override this connection string in your `web.config` file. You do this by first removing the dummy connection string and then adding in the proper one, as shown in the following example:

```
<connectionStrings>
  <remove name="LocalMySqlServer"/>
  <add name="LocalMySqlServer" connectionString="server=xxx;uid=xxx;pwd=xxx;database=xxx"/>
</connectionStrings>
```

> **Note**
>
> You must specify the database in this connection.

A tutorial demonstrating how to use the membership and role providers can be found in the following section Section 6.2.1, “Tutorial: Connector/NET ASP.NET Membership and Role Provider”.

Deployment

To use the providers on a production server, distribute the `MySql.Data` and the `MySql.Web` assemblies, and either register them in the remote systems Global Assembly Cache or keep them in the `bin` directory of your application.

6.2.1 Tutorial: Connector/NET ASP.NET Membership and Role Provider

Many websites feature the facility for the user to create a user account. They can then log into the website and enjoy a personalized experience. This requires that the developer creates database tables to store user information, along with code to gather and process this data. This represents a burden on the developer, and there is the possibility for security issues to creep into the developed code. However, ASP.NET introduced the membership system. This system is designed around the concept of membership, profile, and role providers, which together provide all of the functionality to implement a user system, that previously would have to have been created by the developer from scratch.

Currently, MySQL Connector/NET includes web providers for membership (or simple membership), roles, profiles, session state, site map, and web personalization.

This tutorial shows you how to set up your ASP.NET web application to use the Connector/NET membership and role providers. It assumes that you have MySQL Server installed, along with Connector/NET and Microsoft Visual Studio. This tutorial was tested with Connector/NET 6.0.4 and Microsoft Visual Studio 2008 Professional Edition. It is recommended you use 6.0.4 or above for this tutorial.

1. Create a new MySQL database using the MySQL Command-Line Client program (`mysql`), or other suitable tool. It does not matter what name is used for the database, but record it. You specify it in the connection string constructed later in this tutorial. This database contains the tables, automatically created for you later, used to store data about users and roles.

2. Create a new ASP.NET website in Visual Studio. If you are not sure how to do this, refer to Section 6.4, “Tutorial: Data Binding in ASP.NET Using LINQ on Entities”, which demonstrates how to create a simple ASP.NET website.

3. Add References to `MySql.Data` and `MySql.Web` to the website project.

4. Locate the `machine.config` file on your system, which is the configuration file for the .NET Framework.

5. Search the `machine.config` file to find the membership provider `MySQLMembershipProvider`.

6. Add the attribute `autogenerateschema="true"`. The appropriate section should now resemble the following example.

   > **Note**
   >
   > For the sake of brevity, some information is excluded.

```
<membership>
 <providers>
   <add name="AspNetSqlMembershipProvider"
     type="System.Web.Security.SqlMembershipProvider"
     ...
     connectionStringName="LocalSqlServer"
     ... />
   <add name="MySQLMembershipProvider"
     autogenerateschema="true"
     type="MySql.Web.Security.MySQLMembershipProvider,
           MySql.Web, Version=6.0.4.0, Culture=neutral,
           PublicKeyToken=c5687fc88969c44d"
     connectionStringName="LocalMySqlServer"
     ... />
 </providers>
</membership>
```

   > **Note**
   >
   > The connection string, `LocalMySqlServer`, connects to the MySQL server that contains the membership database.

   The `autogenerateschema="true"` attribute will cause Connector/NET to silently create, or upgrade, the schema on the database server, to contain the required tables for storing membership information.

7. It is now necessary to create the connection string referenced in the previous step. Load the `web.config` file for the website into Visual Studio.

8. Locate the section marked `<connectionStrings>`. Add the following connection string information.

```
<connectionStrings>
```

```
  <remove name="LocalMySqlServer"/>
  <add name="LocalMySqlServer"
       connectionString="Datasource=localhost;Database=users;uid=root;pwd=password"
       providerName="MySql.Data.MySqlClient"/>
</connectionStrings>
```

The database specified is the one created in the first step. You could alternatively have used an existing database.

9. At this point build the solution to ensure no errors are present. This can be done by selecting **Build**, **Build Solution** from the main menu, or pressing **F6**.

10. ASP.NET supports the concept of locally and remotely authenticated users. With local authentication the user is validated using their Windows credentials when they attempt to access the website. This can be useful in an Intranet environment. With remote authentication, a user is prompted for their login details when accessing the website, and these credentials are checked against the membership information stored in a database server such as MySQL Server. You will now see how to choose this form of authentication.

    Start the ASP.NET Website Administration Tool. This can be done quickly by clicking the small hammer/Earth icon in the Solution Explorer. You can also launch this tool by selecting **Website** and then **ASP.NET Configuration** from the main menu.

11. In the ASP.NET Website Administration Tool click the **Security** tab and do the following:

    a. Click the **User Authentication Type** link.

    b. Select the **From the internet** option. The website will now need to provide a form to allow the user to enter their login details. The details will be checked against membership information stored in the MySQL database.

12. You now need to specify the role and membership provider to be used. Click the **Provider** tab and do the following:

    a. Click the **Select a different provider for each feature (advanced)** link.

    b. For membership provider, select the **MySQLMembershipProvider** option and for role provider, select the **MySQLRoleProvider** option.

13. In Visual Studio, rebuild the solution by clicking **Build** and then **Rebuild Solution** from the main menu.

14. Check that the necessary schema has been created. This can be achieved using `SHOW DATABASES;` and `SHOW TABLES;` the `mysql` command interpreter.

```
mysql> SHOW DATABASES;
+--------------------+
| Database           |
+--------------------+
| information_schema |
| mysql              |
| test               |
| users              |
| world              |
+--------------------+
5 rows in set (0.01 sec)

mysql> SHOW TABLES;
+--------------------------+
| Tables_in_users          |
+--------------------------+
| my_aspnet_applications   |
```

```
| my_aspnet_membership      |
| my_aspnet_profiles        |
| my_aspnet_roles           |
| my_aspnet_schemaversion   |
| my_aspnet_users           |
| my_aspnet_usersinroles    |
+---------------------------+
7 rows in set (0.00 sec)
```

15. Assuming all is present and correct, you can now create users and roles for your web application. The easiest way to do this is with the ASP.NET Website Administration Tool. However, many web applications contain their own modules for creating roles and users. For simplicity, the ASP.NET Website Administration Tool will be used in this tutorial.

16. In the ASP.NET Website Administration Tool, click the **Security** tab. Now that both the membership and role provider are enabled, you will see links for creating roles and users. Click the **Create or Manage Roles** link.

17. You can now enter the name of a new Role and click **Add Role** to create the new Role. Create new Roles as required.

18. Click the **Back** button.

19. Click the **Create User** link. You can now fill in information about the user to be created, and also allocate that user to one or more Roles.

20. Using the `mysql` command interpreter, you can check that your database has been correctly populated with the membership and role data.

```
mysql> SELECT * FROM my_aspnet_users;
```

```
mysql>  SELECT * FROM my_aspnet_roles;
```

In this tutorial, you have seen how to set up the Connector/NET membership and role providers for use in your ASP.NET web application.

6.2.2 Tutorial: Connector/NET ASP.NET Profile Provider

This tutorial shows you how to use the MySQL Profile Provider to store user profile information in a MySQL database. The tutorial uses MySQL Connector/NET 6.9.9, MySQL Server 5.7.21 and Microsoft Visual Studio 2017 Professional Edition.

Many modern websites allow the user to create a personal profile. This requires a significant amount of code, but ASP.NET reduces this considerable by including the functionality in its Profile classes. The Profile Provider provides an abstraction between these classes and a data source. The MySQL Profile Provider enables profile data to be stored in a MySQL database. This enables the profile properties to be written to a persistent store, and be retrieved when required. The Profile Provider also enables profile data to be managed effectively, for example it enables profiles that have not been accessed since a specific date to be deleted.

The following steps show you how you can select the MySQL Profile Provider:

1. Create a new ASP.NET web project.

2. Select the MySQL Application Configuration tool.

3. In the MySQL Application Configuration tool navigate through the tool to the Profiles page.

4. Select the **Use MySQL to manage my profiles** check box.

5. Select the **Autogenerate Schema** check box.

6. Click **Edit** and then configure a connection string for the database that will be used to store user profile information.

7. Navigate to the last page of the tool and click **Finish** to save your changes and exit the tool.

At this point you are now ready to start using the MySQL Profile Provider. With the following steps you can carry out a preliminary test of your installation.

1. Open your `web.config` file.

2. Add a simple profile such as the following example.

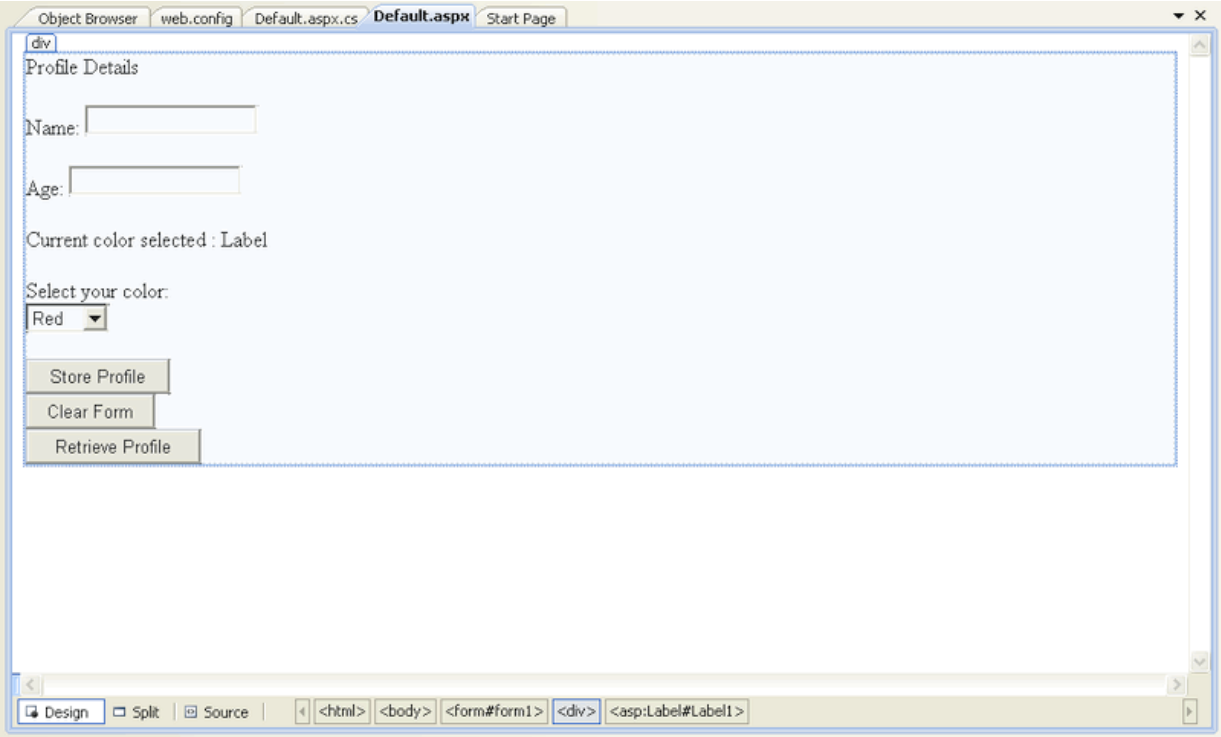
```
<system.web>
  <anonymousIdentification enabled="true"/>
  <profile defaultProvider="MySQLProfileProvider">
    ...
    <properties>
      <add name="Name" allowAnonymous="true"/>
      <add name="Age" allowAnonymous="true" type="System.UInt16"/>
      <group name="UI">
        <add name="Color" allowAnonymous="true" defaultValue="Blue"/>
        <add name="Style" allowAnonymous="true" defaultValue="Plain"/>
      </group>
    </properties>
  </profile>
  ...
```

   Setting `anonymousIdentification` to true enables unauthenticated users to use profiles. They are identified by a GUID in a cookie rather than by a user name.

Now that the simple profile has been defined in `web.config`, the next step is to write some code to test the profile.

1. In Design View, design a simple page with the added controls. The following figure shows the **Default.aspx** tab open with various text box, list, and button controls.

Figure 6.2 Simple Profile Application



These will allow the user to enter some profile information. The user can also use the buttons to save their profile, clear the page, and restore their profile data.

2. In the Code View add the following code snippet.

```
...
protected void Page_Load(object sender, EventArgs e)
{
    if (!IsPostBack)
    {
        TextBox1.Text = Profile.Name;
        TextBox2.Text = Profile.Age.ToString();
        Label1.Text = Profile.UI.Color;
    }
}

// Store Profile
protected void Button1_Click(object sender, EventArgs e)
{
    Profile.Name = TextBox1.Text;
    Profile.Age = UInt16.Parse(TextBox2.Text);
}

// Clear Form
protected void Button2_Click(object sender, EventArgs e)
{
    TextBox1.Text = "";
    TextBox2.Text = "";
    Label1.Text = "";
}

// Retrieve Profile
protected void Button3_Click(object sender, EventArgs e)
```

```
{
    TextBox1.Text = Profile.Name;
    TextBox2.Text = Profile.Age.ToString();
    Label1.Text = Profile.UI.Color;
}

protected void DropDownList1_SelectedIndexChanged(object sender, EventArgs e)
{
    Profile.UI.Color = DropDownList1.SelectedValue;
}
...
```

3. Save all files and build the solution to check that no errors have been introduced.
4. Run the application.
5. Enter your name, age, and select a color from the list. Now store this information in your profile by clicking **Store Profile**.

   Not selecting a color from the list uses the default color, *Blue*, that was specified in the `web.config` file.
6. Click **Clear Form** to clear text from the text boxes and the label that displays your chosen color.
7. Now click **Retrieve Profile** to restore your profile data from the MySQL database.
8. Now exit the browser to terminate the application.
9. Run the application again, which also restores your profile information from the MySQL database.

In this tutorial you have seen how to using the MySQL Profile Provider with Connector/NET.

6.2.3 Tutorial: Web Parts Personalization Provider

MySQL Connector/NET provides a web parts personalization provider that allows you to use a MySQL server to store personalization data.

> **Note**
>
> This feature was added in Connector/NET 6.9.0.

This tutorial demonstrates how to configure the web parts personalization provider using Connector/NET.

Minimum Requirements

- An ASP.NET website or web application with a membership provider
- .NET Framework 3.0
- MySQL 5.5

Configuring MySQL Web Parts Personalization Provider

To configure the provider, do the following:

1. Add References to `MySql.Data` and `MySql.Web` to the website or web application project.
2. Include a Connector/NET personalization provider into the `system.web` section in the `web.config` file.

```
<webParts>
 <personalization defaultProvider="MySQLPersonalizationProvider">
  <providers>
```

```
    <clear/>
    <add name="MySQLPersonalizationProvider"
      type="MySql.Web.Personalization.MySqlPersonalizationProvider,
        MySql.Web, Version=6.9.3.0, Culture=neutral,
        PublicKeyToken=c5687fc88969c44d"
      connectionStringName="LocalMySqlServer"
      applicationName="/" />
  </providers>
  <authorization>
    <allow verbs="modifyState" users="*" />
    <allow verbs="enterSharedScope" users="*"/>
  </authorization>
 </personalization>
</webParts>
```

Creating Web Part Controls

To create the web part controls, follow these steps:

1. Create a web application using Connector/NET ASP.NET Membership. For information about doing this, see Section 6.2.1, “Tutorial: Connector/NET ASP.NET Membership and Role Provider”.
2. Create a new ASP.NET page and then change to the Design view.
3. From the **Toolbox**, drag a **WebPartManager** control to the page.
4. Now define an HTML table with three columns and one row.
5. From the **WebParts Toolbox**, drag and drop a `WebPartZone` control into both the first and second columns.
6. From the **WebParts Toolbox**, drag and drop a `CatalogZone` with `PageCatalogPart` and `EditorZone` controls into the third column.
7. Add controls to the `WebPartZone`, which should look similar to the following example:

```
<table>
  <tr>
    <td>
      <asp:WebPartZone ID="LeftZone" runat="server" HeaderText="Left Zone">
        <ZoneTemplate>
          <asp:Label ID="Label1" runat="server" title="Left Zone">
            <asp:BulletedList ID="BulletedList1" runat="server">
              <asp:ListItem Text="Item 1"></asp:ListItem>
              <asp:ListItem Text="Item 2"></asp:ListItem>
              <asp:ListItem Text="Item 3"></asp:ListItem>
            </asp:BulletedList>
          </asp:Label>
        </ZoneTemplate>
      </asp:WebPartZone>
    </td>
    <td>
      <asp:WebPartZone ID="MainZone" runat="server" HeaderText="Main Zone">
        <ZoneTemplate>
          <asp:Label ID="Label11" runat="server" title="Main Zone">
            <h2>This is the Main Zone</h2>
          </asp:Label>
        </ZoneTemplate>
      </asp:WebPartZone>
    </td>
    <td>
      <asp:CatalogZone ID="CatalogZone1" runat="server">
        <ZoneTemplate>
          <asp:PageCatalogPart ID="PageCatalogPart1" runat="server" />
        </ZoneTemplate>
```

```
      </asp:CatalogZone>
      <asp:EditorZone ID="EditorZone1" runat="server">
        <ZoneTemplate>
          <asp:LayoutEditorPart ID="LayoutEditorPart1" runat="server" />
          <asp:AppearanceEditorPart ID="AppearanceEditorPart1" runat="server" />
        </ZoneTemplate>
      </asp:EditorZone>
    </td>
  </tr>
</table>
```

8. Outside of the HTML table, add a drop-down list, two buttons, and a label as follows.

```
<asp:DropDownList ID="DisplayModes" runat="server" AutoPostBack="True"
   OnSelectedIndexChanged="DisplayModes_SelectedIndexChanged">
</asp:DropDownList>
<asp:Button ID="ResetButton" runat="server" Text="Reset"
   OnClick="ResetButton_Click" />
<asp:Button ID="ToggleButton" runat="server" OnClick="ToggleButton_Click"
   Text="Toggle Scope" />
<asp:Label ID="ScopeLabel" runat="server"></asp:Label>
```

9. The following code fills the list for the display modes, shows the current scope, resets the personalization state, toggles the scope (between user and the shared scope), and changes the display mode.

```
public partial class WebPart : System.Web.UI.Page
{
  protected void Page_Load(object sender, EventArgs e)
  {
    if (!IsPostBack)
    {
      foreach (WebPartDisplayMode mode in WebPartManager1.SupportedDisplayModes)
      {
        if (mode.IsEnabled(WebPartManager1))
        {
          DisplayModes.Items.Add(mode.Name);
        }
      }
    }
    ScopeLabel.Text = WebPartManager1.Personalization.Scope.ToString();
  }

  protected void ResetButton_Click(object sender, EventArgs e)
  {
    if (WebPartManager1.Personalization.IsEnabled &&
      WebPartManager1.Personalization.IsModifiable)
    {
      WebPartManager1.Personalization.ResetPersonalizationState();
    }
  }

  protected void ToggleButton_Click(object sender, EventArgs e)
  {
    WebPartManager1.Personalization.ToggleScope();
  }

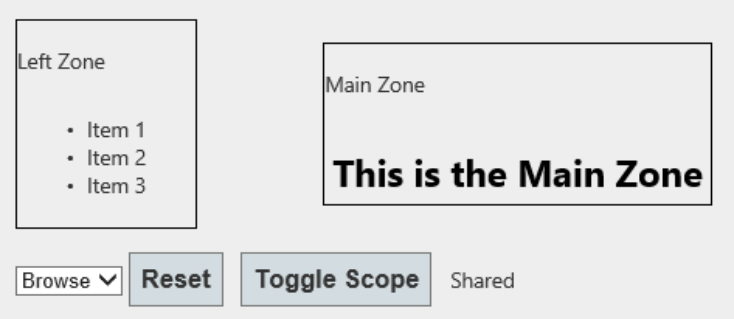
  protected void DisplayModes_SelectedIndexChanged(object sender, EventArgs e)
  {
    var mode = WebPartManager1.SupportedDisplayModes[DisplayModes.SelectedValue];
    if (mode != null && mode.IsEnabled(WebPartManager1))
    {
      WebPartManager1.DisplayMode = mode;
    }
  }
}
```

Testing Web Part Changes

Use the following steps to validate your changes:

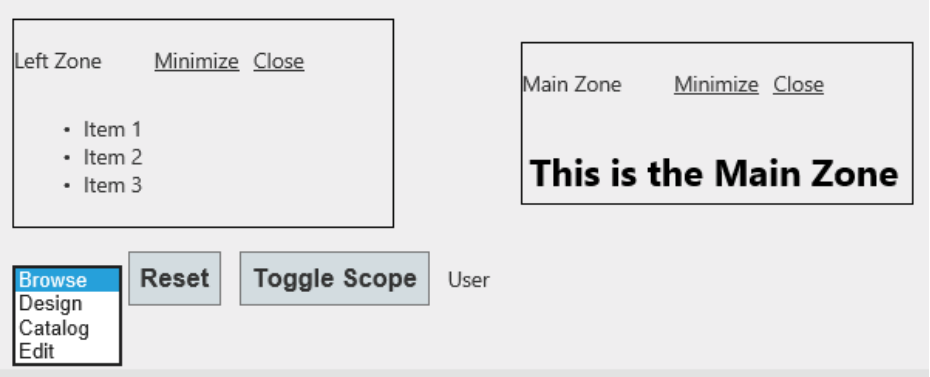
1. Run the application and open the web part page. The page should look like similar to the example shown in the following figure in which the Toggle Scope button is set to `Shared`. The page also includes the drop-down list, the Reset button, and the Left Zone and Main Zone controls.

Figure 6.3 Web Parts Page



Initially when the user account is not authenticated, the scope is *Shared* by default. The user account must be authenticated to change settings on the web-part controls. The following figure shows an example in which an authenticated user is able to customize the controls by using the Browse drop-down list. The options in the list are `Design`, `Catalog`, and `Edit`.

Figure 6.4 Authenticated User Controls



2. Click **Toggle Scope** to switch the application back to the shared scope.

3. Now you can personalize the zones using the `Edit` or `Catalog` display modes at a specific user or all-users level. The next figure shows `Catalog` selected from the drop-down list, which include the Catalog Zone control that was added previously.

Figure 6.5 Personalize Zones



6.2.4 Tutorial: Simple Membership Web Provider

This section documents the ability to use a simple membership provider on MVC 4 templates. The configuration OAuth compatible for the application to login using external credentials from third-party providers like Google, Facebook, Twitter, or others.

This tutorial creates an application using a simple membership provider and then adds third-party (Google) OAuth authentication support.

> **Note**
>
> This feature was added in MySQL Connector/NET 6.9.0.

Requirements

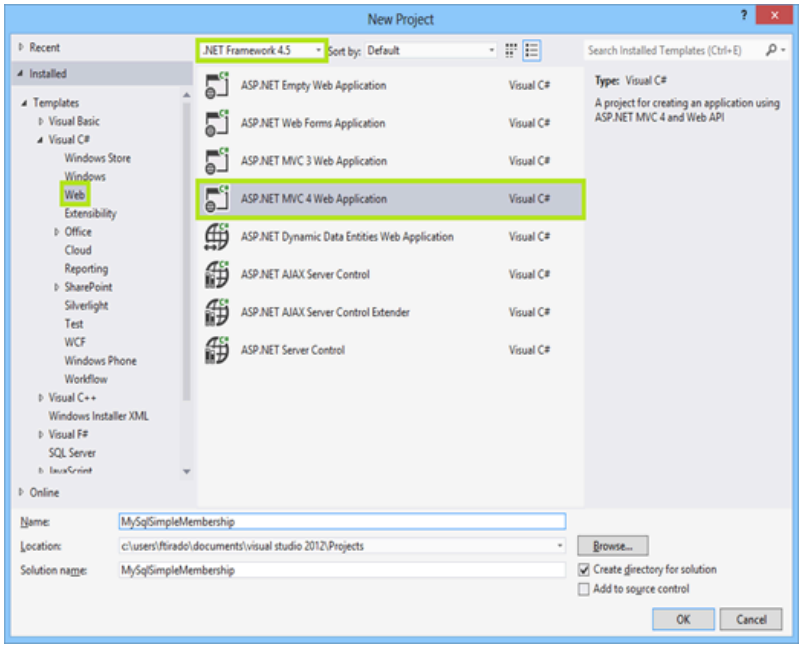
- Connector/NET 6.9.x or later
- .NET Framework 4.0 or later
- Visual Studio 2012 or later
- MVC 4

Creating and Configuring a New Project

To get started with a new project, do the following:

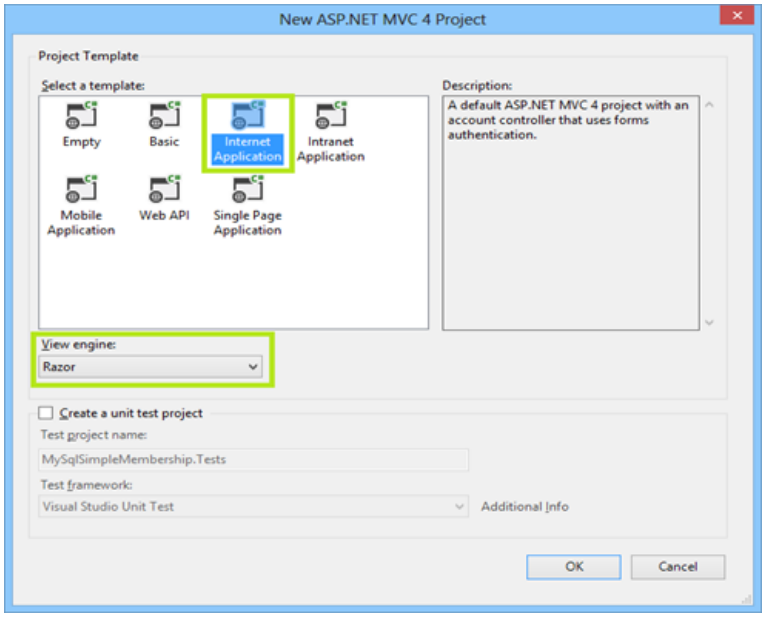
1. Open Visual Studio, create a new project of **ASP.NET MVC 4 Web Application** type, and configure the project to use .NET Framework 4.5. The following figure shows and example of the New Project window with the items selected.

Figure 6.6 Simple Membership: New Project



2. Choose the template and view engine that you like. This tutorial uses the **Internet Application Template** with the Razor view engine (see the next figure). Optionally, you can add a unit test project by selecting **Create a unit test project**.

Figure 6.7 Simple Membership: Choose Template and Engine



3. Add references to the `MySql.Data`, `MySql.Data.Entities`, and `MySql.Web` assemblies. The assemblies chosen must match the .NET Framework and Entity Framework versions added to the project by the template.

4. Add a valid MySQL connection string to the `web.config` file, similar to the following example.

```
<add
  name="MyConnection"
  connectionString="server=localhost;
                    UserId=root;
                    password=pass;
                    database=MySqlSimpleMembership;
                    logging=true;port=3305"
  providerName="MySql.Data.MySqlClient"/>
```

5. Under the `<system.data>` node, add configuration information similar to the following example.

```
<membership defaultProvider="MySqlSimpleMembershipProvider">
<providers>
<clear/>
<add
  name="MySqlSimpleMembershipProvider"
  type="MySql.Web.Security.MySqlSimpleMembershipProvider,MySql.Web,
        Version=6.9.2.0,Culture=neutral,PublicKeyToken=c5687fc88969c44d"
  applicationName="MySqlSimpleMembershipTest"
  description="MySQLdefaultapplication"
  connectionStringName="MyConnection"
  userTableName="MyUserTable"
  userIdColumn="MyUserIdColumn"
  userNameColumn="MyUserNameColumn"
  autoGenerateTables="True"/>
</providers>
</membership>
```

6. Update the configuration with valid values for the following properties: `connectionStringName`, `userTableName`, `userIdColumn`, `userNameColumn`, and `autoGenerateTables`.

   - `userTableName`: Name of the table to store the user information. This table is independent from the schema generated by the provider, and it can be changed in the future.
   - `userId`: Name of the column that stores the ID for the records in the `userTableName`.
   - `userName`: Name of the column that stores the name/user for the records in the `userTableName`.
   - `connectionStringName`: This property must match a connection string defined in `web.config` file.
   - `autoGenerateTables`: This must be set to `false` if the table to handle the credentials already exists.

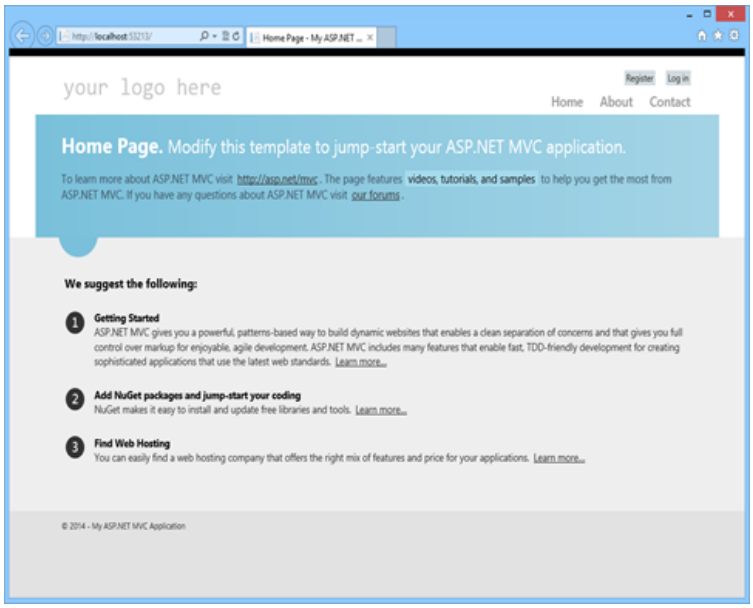
7. Update your `DBContext` class with the connection string name configured.

8. Open the `InitializeSimpleMembershipAttribute.cs` file from the `Filters/` folder and locate the `SimpleMembershipInitializer` class. Then find the `WebSecurity.InitializeDatabaseConnection` method call and update the parameters with the configuration for `connectionStringName`, `userTableName`, `userIdColumn`, and `userNameColumn`.

9. If the database configured in the connection string does not exist, then create it.

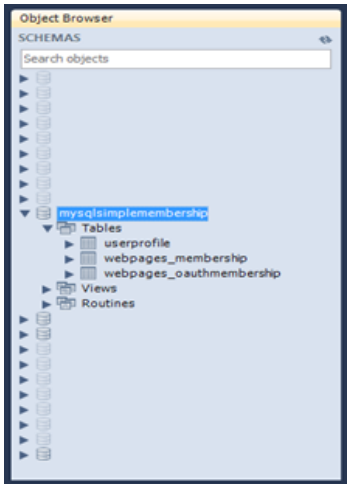
10. After running the web application, the generated home page is displayed on success (see the figure that follows).

Figure 6.8 Simple Membership: Generated Home Page



11. If the application executed with success, then the generated schema will be similar to the following figure showing an object browser open to the tables.

Figure 6.9 Simple Membership: Generated Schema and Tables



12. To create a user login, click **Register** on the generated web page. Type the user name and password, and then execute the registration form. This action redirects you to the home page with the newly created user logged in.

    The data for the newly created user can be located in the `UserProfile` and `Webpages_Membership` tables.

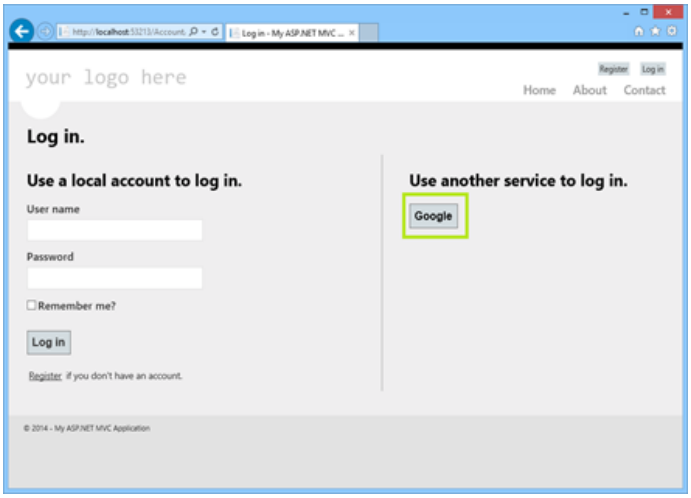
Adding OAuth Authentication to a Project

OAuth is another authentication option for websites that use the simple membership provider. A user can be validated using an external account like Facebook, Twitter, Google, and others.

Use the following steps to enable authentication using a Google account in the application:

1. Locate the `AuthConfig.cs` file in the `App_Start` folder.
2. As this tutorial uses Google, find the `RegisterAuth` method and uncomment the last line where it calls `OauthWebSecurity.RegisterGoogleClient`.
3. Run the application. When the application is running, click **Log in** to open the log in page. Then, click **Google** under **Use another service to log in** (shown in the figure that follows).

Figure 6.10 Simple Membership with OAuth: Google Service



4. This action redirects to the Google login page (at google.com), and requests you to sign in with your Google account information.
5. After submitting the correct credentials, a message requests permission for your application to access the user's information. Read the description and then click **Accept** to allow the quoted actions, and to redirect back to the login page of the application.
6. The application now can register the account. The **User name** field will be filled in with the appropriate information (in this case, the email address that is associated with the Google account). Click **Register** to register the user with your application.

   Now the new user is logged into the application from an external source using OAuth. Information about the new user is stored in the `UserProfile` and `Webpages_OauthMembership` tables.

To use another external option to authenticate users, you must enable the client in the same class where we enabled the Google provider in this tutorial. Typically, providers require you to register your application before allowing OAuth authentication, and once registered they typically provide a token/key and an ID that must be used when registering the provider in the application.

6.3 Tutorial: Using an Entity Framework Entity as a Windows Forms Data Source

This tutorial describes how to create a Windows Forms Data Source from an Entity in an Entity Data Model using Microsoft Visual Studio. The steps are:

- Creating a New Windows Forms Application
- Adding an Entity Data Model
- Adding a New Data Source
- Using the Data Source in a Windows Form
- Adding Code to Populate the Data Grid View
- Adding Code to Save Changes to the Database

To perform the steps in this tutorial, first install the `world` database sample, which you may download from the MySQL Documentation page. You can also find details on how to install the database on the same page.

Creating a New Windows Forms Application

The first step is to create a new Windows Forms application.

1. In Visual Studio, select **File**, **New**, and then **Project** from the main menu.
2. Choose the **Windows Forms Application** installed template. Click **OK**. The solution is created.

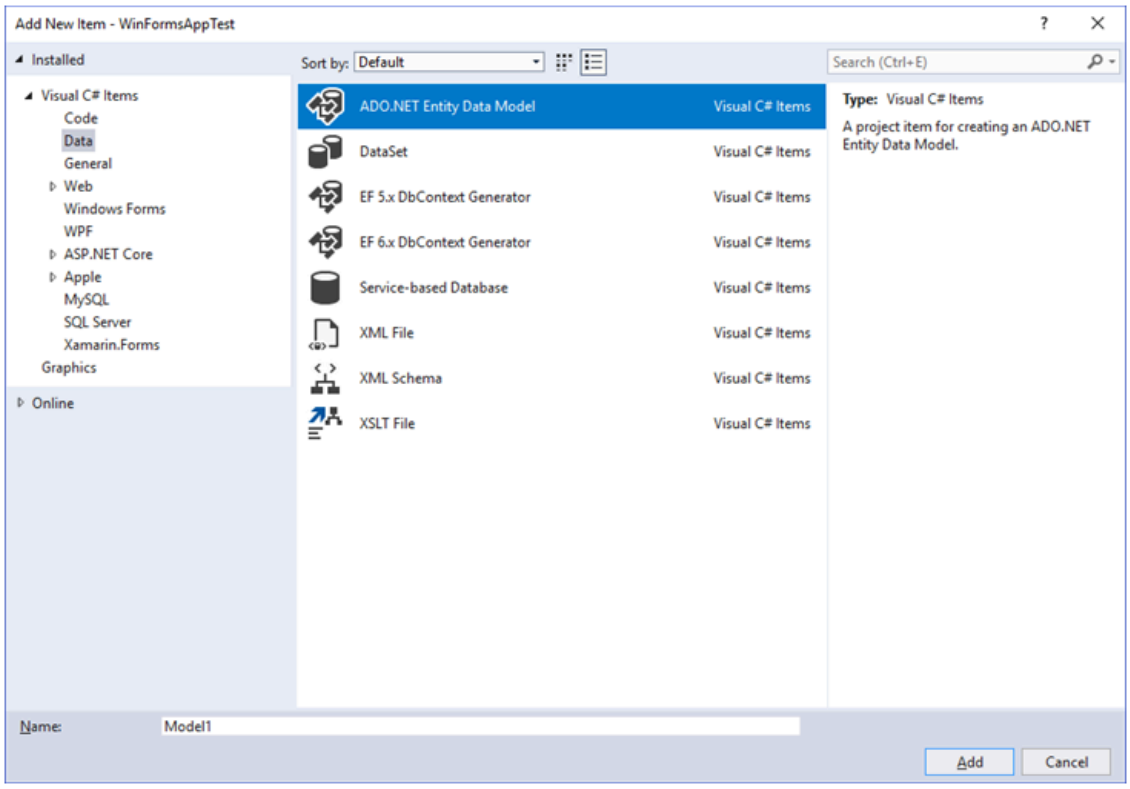
To acquire the latest Entity Framework assembly for MySQL, download the NuGet package.

Adding an Entity Data Model

To add an Entity Data Model to your solution, do the following:

1. In the Solution Explorer, right-click your application and select **Add** and then **New Item**. From **Visual Studio installed templates**, select **ADO.NET Entity Data Model** (see the figure that follows). Click **Add**.

Figure 6.11 Add Entity Data Model



2. You will now see the Entity Data Model Wizard. You will use the wizard to generate the Entity Data Model from the `world` database sample. Select the icon **EF Designer from database** (or **Generate from database** in older versions of Visual Studio). Click **Next**.

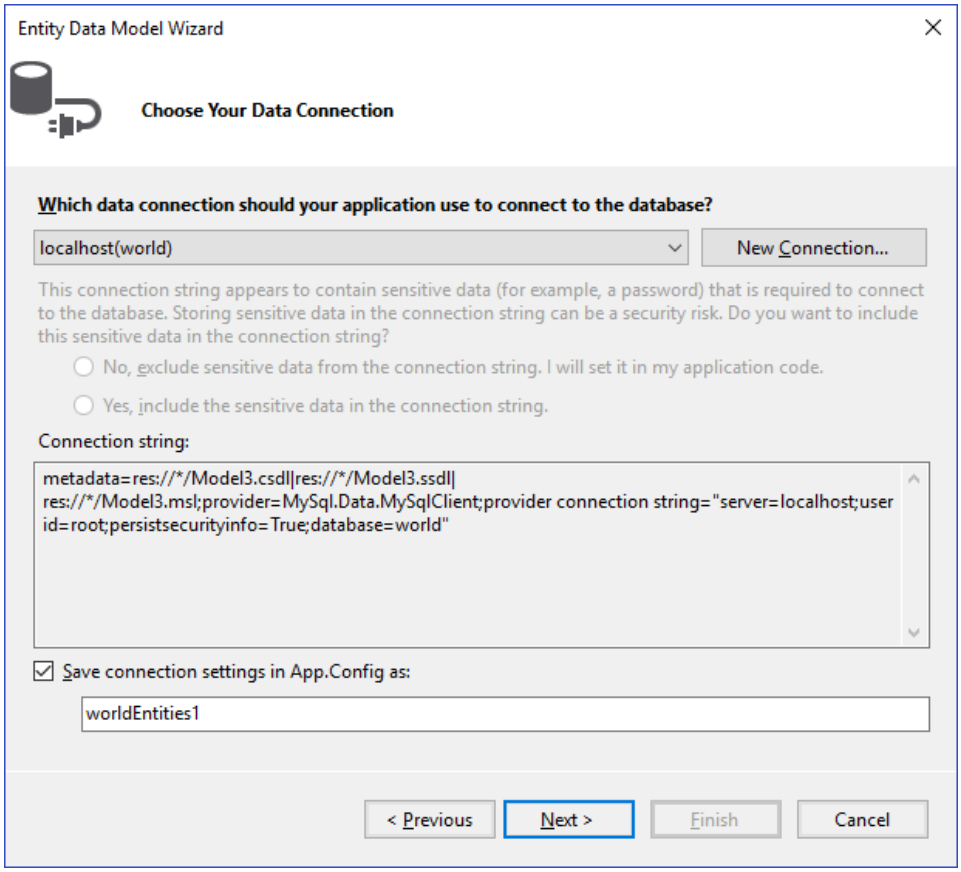
3. You can now select the `localhost(world)` connection you made earlier to the database. Select the following items:

   - Yes, include the sensitive data in the connection string.
   - Save entity connection settings in `App.config` as:

     `worldEntities`

   If you have not already done so, you can create the new connection at this time by clicking **New Connection** (see the figure that follows).

Figure 6.12 Entity Data Model Wizard - Connection



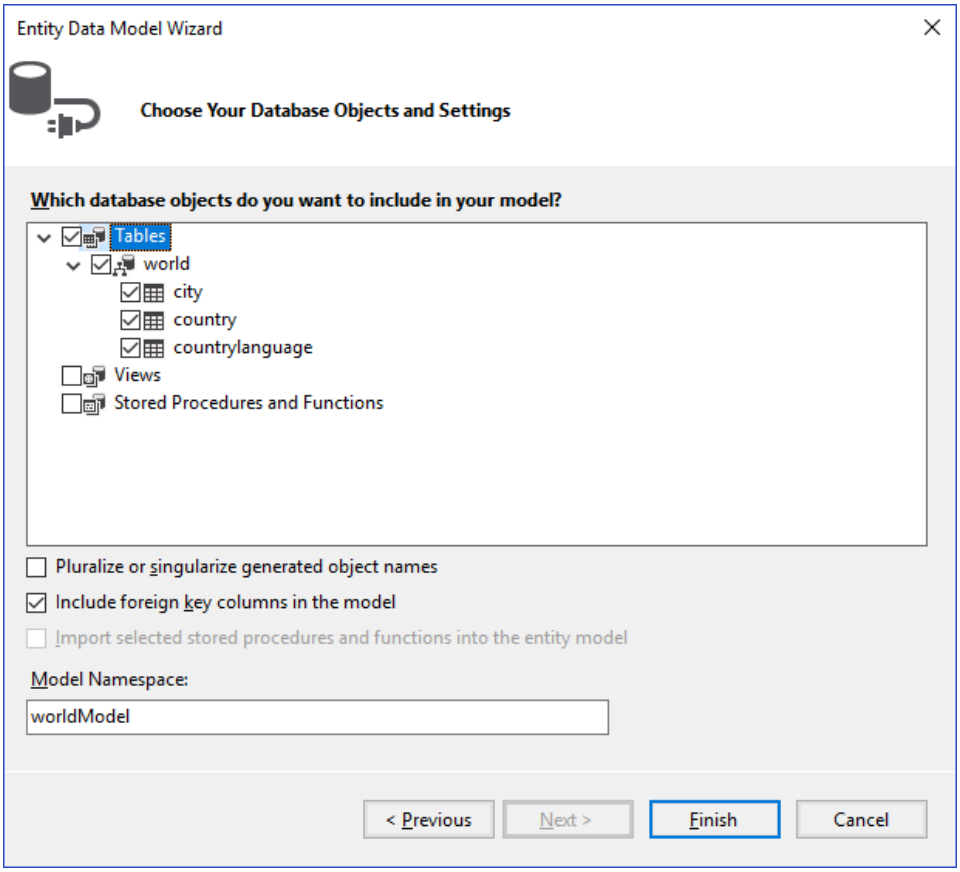
Make a note of the entity connection settings to be used in `App.Config`, as these will be used later to write the necessary control code. Click **Next**.

4. The Entity Data Model Wizard connects to the database.

   As the next figure shows, you are then presented with a tree structure of the database. From here you can select the object you would like to include in your model. If you also created Views and Stored

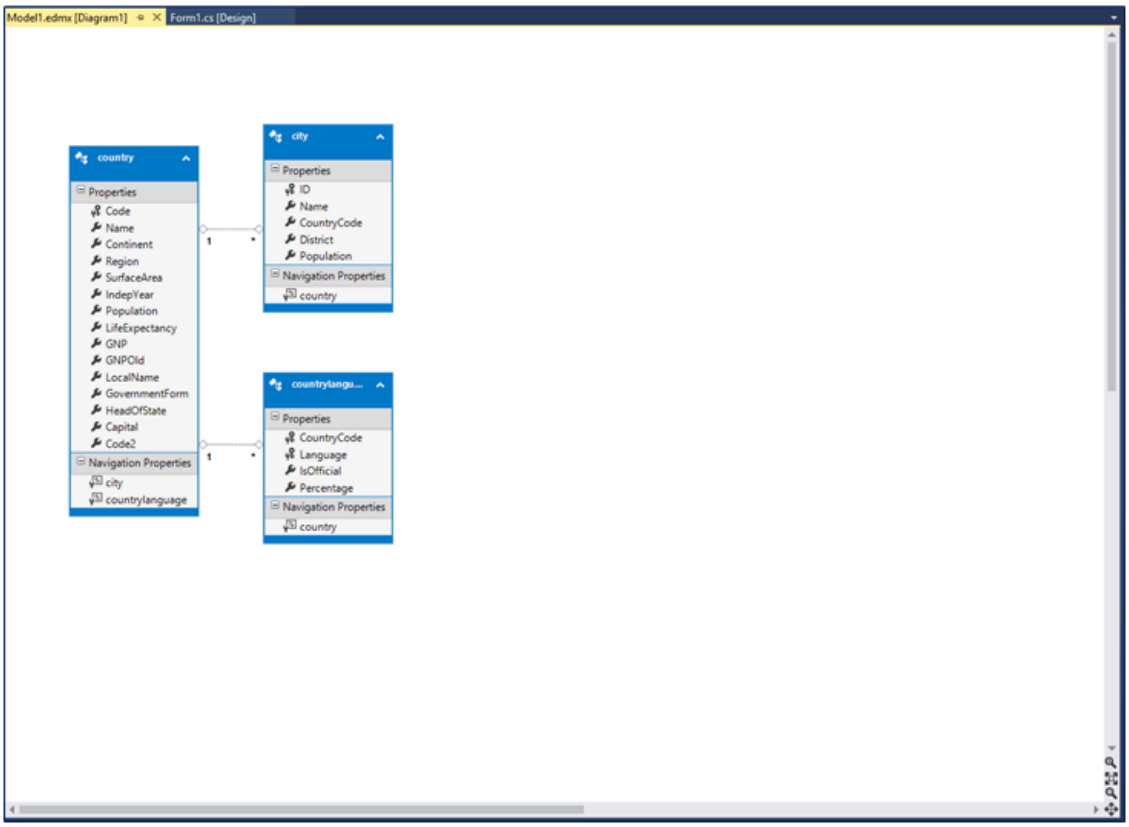
Routines, these items will be displayed along with any tables. In this example you just need to select the tables. Click **Finish** to create the model and exit the wizard.

Figure 6.13 Entity Data Model Wizard - Objects and Settings



Visual Studio generates a model with three tables (city, country, and countrylanguage) and then display it, as the following figure shows.

Figure 6.14 Entity Data Model Diagram



5. From the Visual Studio main menu, select **Build** and then **Build Solution** to ensure that everything compiles correctly so far.

Adding a New Data Source

You will now add a new Data Source to your project and see how it can be used to read and write to the database.

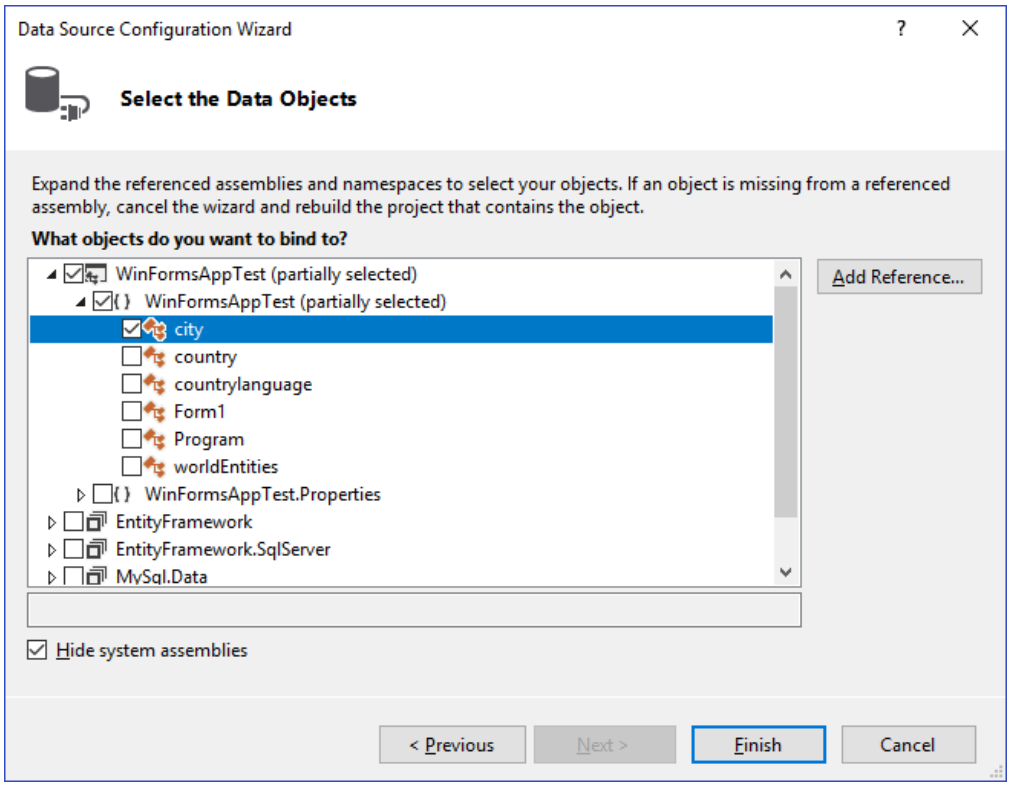
1. From the Visual Studio main menu select **Data** and then **Add New Data Source**. You will be presented with the Data Source Configuration Wizard.

2. Select the **Object** icon. Click **Next**.

3. Select the object to bind to. Expand the tree as the next figure shows.

   In this tutorial, you will select the city table. After the city table has been selected click **Next**.

Figure 6.15 Data Source Configuration Wizard



4. The wizard will confirm that the city object is to be added. Click **Finish**.

5. The city object will now appear in the Data Sources panel. If the Data Sources panel is not displayed, select **Data** and then **Show Data Sources** from the Visual Studio main menu. The docked panel will then be displayed.

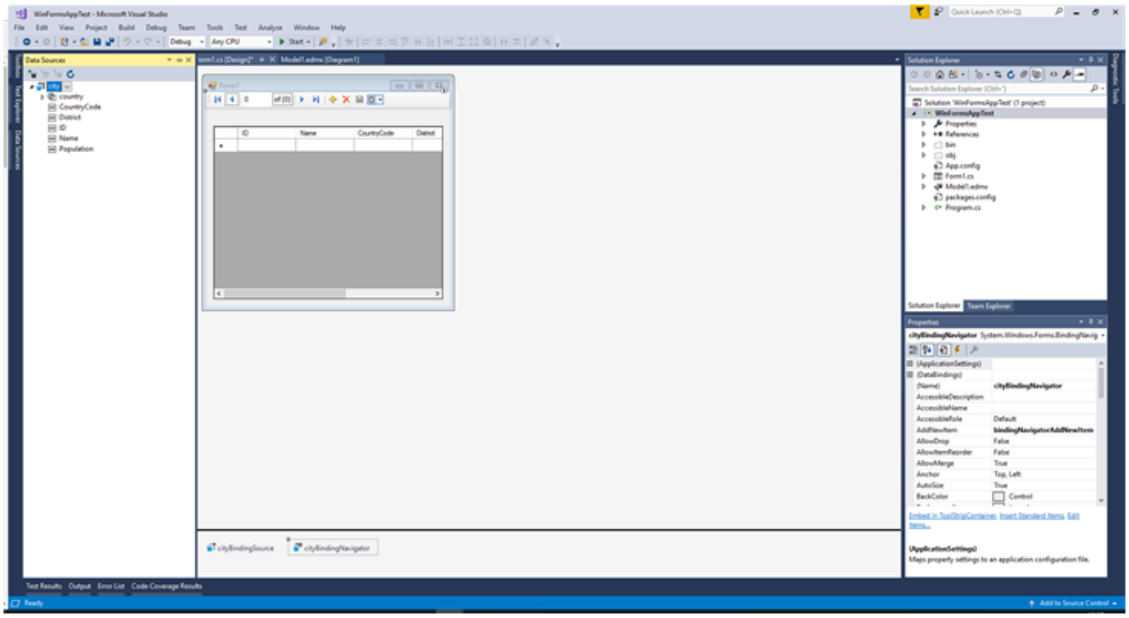
Using the Data Source in a Windows Form

This step describes how to use the Data Source in a Windows Form.

1. In the Data Sources panel select the Data Source you just created and drag and drop it onto the Form Designer. By default, the Data Source object will be added as a Data Grid View control as the following figure shows.

> **Note**
>
> The Data Grid View control is bound to `cityBindingSource`, and the Navigator control is bound to `cityBindingNavigator`.

Figure 6.16 Data Form Designer



2. Save and rebuild the solution before continuing.

Adding Code to Populate the Data Grid View

You are now ready to add code to ensure that the Data Grid View control will be populated with data from the city database table.

1. Double-click the form to access its code.
2. Add the following code to instantiate the Entity Data Model `EntityContainer` object and retrieve data from the database to populate the control.

```
using System.Windows.Forms;

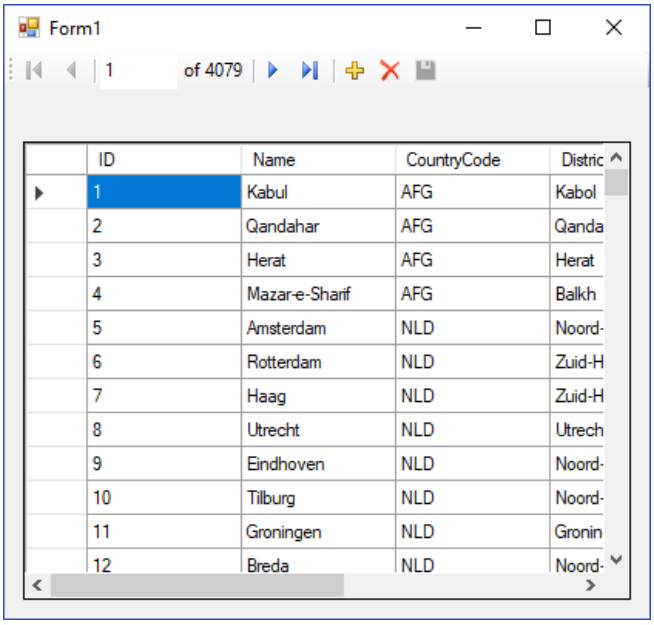
namespace WindowsFormsApplication4
{
   public partial class Form1 : Form
   {
      worldEntities we;

      public Form1()
      {
          InitializeComponent();
      }

      private void Form1_Load(object sender, EventArgs e)
      {
          we = new worldEntities();
          cityBindingSource.DataSource = we.city.ToList();
      }
   }
}
```

3. Save and rebuild the solution.
4. Run the solution. Confirm that the grid is populated (see the next figure for an example) and that you can navigate the database.

Figure 6.17 The Populated Grid Control



Adding Code to Save Changes to the Database

This step explains how to add code that enables you to save changes to the database.

The Binding source component ensures that changes made in the Data Grid View control are also made to the Entity classes bound to it. However, that data needs to be saved back from the entities to the database itself. This can be achieved by the enabling of the Save button in the Navigator control, and the addition of some code.

1. In the Form Designer, click the save icon in the form toolbar and confirm that its **Enabled** property is set to `True`.
2. Double-click the save icon in the form toolbar to display its code.
3. Add the following (or similar) code to ensure that data is saved to the database when a user clicks the save button in the application.

```
      public Form1()
      {
          InitializeComponent();
      }

      private void Form1_Load(object sender, EventArgs e)
      {
          we = new worldEntities();
          cityBindingSource.DataSource = we.city.ToList();
      }
      private void cityBindingNavigatorSaveItem_Click(object sender, EventArgs e)
      {
          we.SaveChanges();
      }
   }
}
```

4. When the code has been added, save the solution and then rebuild it. Run the application and verify that changes made in the grid are saved.

6.4 Tutorial: Data Binding in ASP.NET Using LINQ on Entities

In this tutorial you create an ASP.NET web page that binds LINQ queries to entities using the Entity Framework mapping with MySQL Connector/NET.

If you have not already done so, install the `world` database sample prior to attempting this tutorial. See the tutorial Section 6.3, “Tutorial: Using an Entity Framework Entity as a Windows Forms Data Source” for instructions on downloading and installing this database.

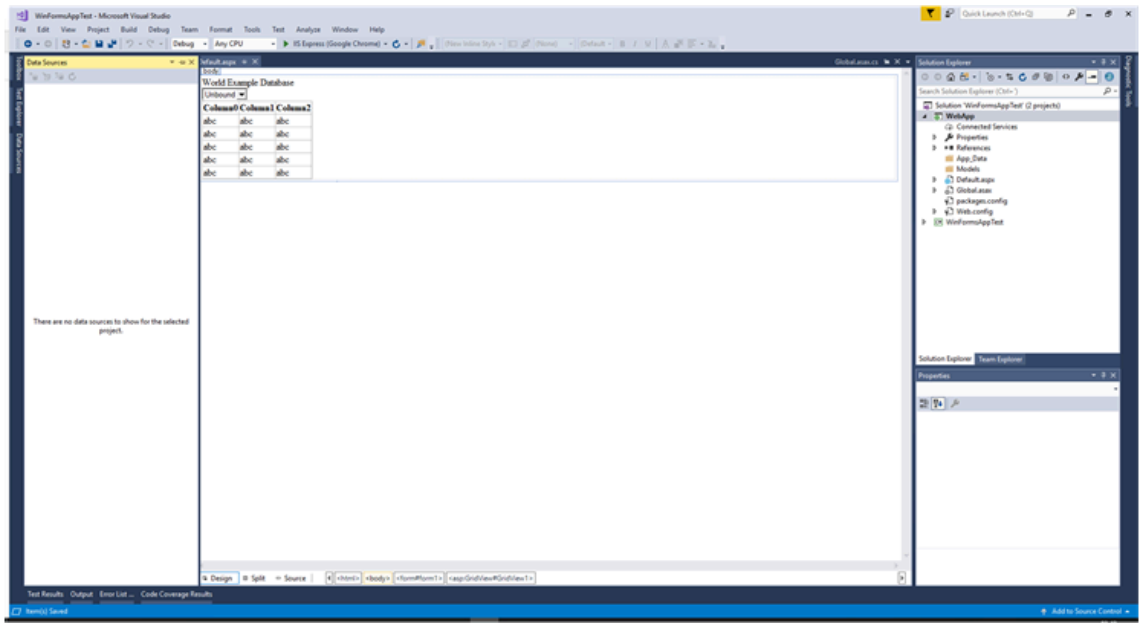
Creating an ASP.NET Website

In this part of the tutorial, you create an ASP.NET website. The website uses the `world` database. The main web page features a drop-down list from which you can select a country. Data about the cities of that country is then displayed in a GridView control.

1. From the Visual Studio main menu select **File**, **New**, and then **Web Site**.
2. From the Visual Studio installed templates select **ASP.NET Web Site**. Click **OK**. You will be presented with the Source view of your web page by default.
3. Click the Design view tab situated underneath the Source view panel.
4. In the Design view panel, enter some text to decorate the blank web page.
5. Click **Toolbox**. From the list of controls, select **DropDownList**. Drag and drop the control to a location beneath the text on your web page.
6. From the **DropDownList** control context menu, ensure that the **Enable AutoPostBack** check box is enabled. This will ensure the control's event handler is called when an item is selected. The user's choice will in turn be used to populate the **GridView** control.
7. From the Toolbox select the **GridView** control. Drag and drop the **GridView** control to a location just below the drop-down list you already placed.

   The following figure shows an example of the decorative text and two controls in the Design view tab. The added GridView control produced a grid with three columns (`Column0`, `Column1`, and `Column3`) and the string `abc` in each cell of the grid.

Figure 6.18 Placed GridView Control



8. At this point it is recommended that you save your solution, and build the solution to ensure that there are no errors.

9. If you run the solution you will see that the text and drop down list are displayed, but the list is empty. Also, the grid view does not appear at all. Adding this functionality is described in the following sections.

At this stage you have a website that will build, but further functionality is required. The next step will be to use the Entity Framework to create a mapping from the `world` database into entities that you can control programmatically.

Creating an ADO.NET Entity Data Model

In this stage of the tutorial you will add an ADO.NET Entity Data Model to your project, using the `world` database at the storage level. The procedure for doing this is described in the tutorial Section 6.3, “Tutorial: Using an Entity Framework Entity as a Windows Forms Data Source”, and so will not be repeated here.

Populating a List Box by Using the Results of a Entity LINQ Query

In this part of the tutorial you will write code to populate the **DropDownList** control. When the web page loads the data to populate the list will be achieved by using the results of a LINQ query on the model created previously.

1. In the Design view panel, double-click any blank area. This brings up the `Page_Load` method.

2. Modify the relevant section of code according to the following listing example.

```
...
public partial class _Default : System.Web.UI.Page
{
    worldModel.worldEntities we;

    protected void Page_Load(object sender, EventArgs e)
    {
```

```
        we = new worldModel.worldEntities();

        if (!IsPostBack)
        {
            var countryQuery = from c in we.country
                               orderby c.Name
                               select new { c.Code, c.Name };
            DropDownList1.DataValueField = "Code";
            DropDownList1.DataTextField = "Name";
            DropDownList1.DataSource = countryQuery.ToList();
            DataBind();
        }
    }
...
```

The list control only needs to be populated when the page first loads. The conditional code ensures that if the page is subsequently reloaded, the list control is not repopulated, which would cause the user selection to be lost.

3. Save the solution, build it and run it. You should see that the list control has been populated. You can select an item, but as yet the GridView control does not appear.

At this point you have a working Drop Down List control, populated by a LINQ query on your entity data model.

Populating a Grid View Control by Using an Entity LINQ Query

In the last part of this tutorial you will populate the Grid View Control using a LINQ query on your entity data model.

1. In the Design view, double-click the **DropDownList** control. This action causes its `SelectedIndexChanged` code to be displayed. This method is called when a user selects an item in the list control and thus generates an AutoPostBack event.

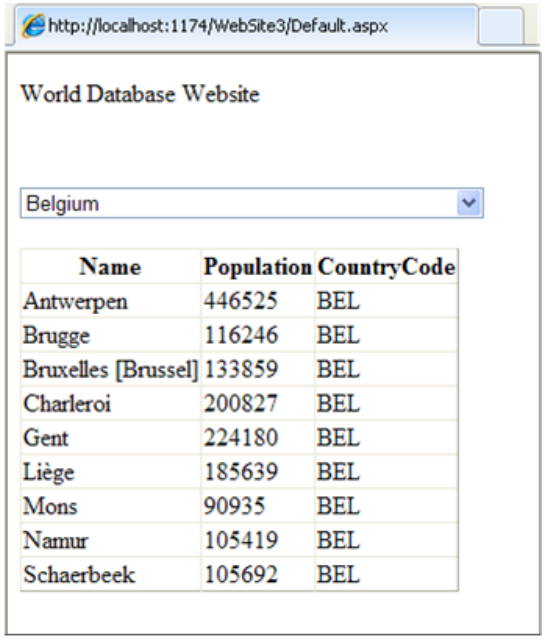
2. Modify the relevant section of code accordingly to the following listing example.

```
...
    protected void DropDownList1_SelectedIndexChanged(object sender, EventArgs e)
    {
        var cityQuery = from c in we.city
                        where c.CountryCode == DropDownList1.SelectedValue
                        orderby c.Name
                        select new { c.Name, c.Population, c.CountryCode };
        GridView1.DataSource = cityQuery;
        DataBind();
    }
...
```

The grid view control is populated from the result of the LINQ query on the entity data model.

3. Save, build, and run the solution. As you select a country you will see its cities are displayed in the GridView control. The following figure shows Belgium selected from the list box and a table with three columns: `Name`, `Population`, and `CountryCode`.

Figure 6.19 The Working Website



In this tutorial you have seen how to create an ASP.NET website, you have also seen how you can access a MySQL database using LINQ queries on an entity data model.

6.5 Tutorial: Generating MySQL DDL from an Entity Framework Model

This tutorial demonstrates how to create MySQL DDL from an Entity Framework model. Minimally, you will need Microsoft Visual Studio 2017 and MySQL Connector/NET 6.10 to perform this tutorial.

1. Create a new console application in Visual Studio 2017.
2. Using the **Solution Explorer**, add a reference to `MySql.Data.Entity`.
3. From the **Solution Explorer** select **Add**, **New Item**. In the **Add New Item** dialog select **Online Templates**. Select **ADO.NET Entity Data Model** and click **Add** to open the **Entity Data Model** dialog.
4. In the **Entity Data Model** dialog select **Empty Model**. Click **Finish** to create a blank model.
5. Create a simple model. A single Entity will do for the purposes of this tutorial.
6. In the **Properties** panel select **ConceptualEntityModel** from the drop-down list.
7. In the **Properties** panel, locate the **DDL Generation Template** in the category **Database Script Generation**.
8. For the **DDL Generation** property select **SSDLToMySQL.tt(VS)** from the drop-down list.
9. Save the solution.
10. Right-click an empty space in the model design area to open the context-sensitive menu. From the menu select **Generate Database from Model** to open the **Generate Database Wizard** dialog.

11. In the **Generate Database Wizard** dialog select an existing connection, or create a new connection to a server. Select an appropriate option to show or hide sensitive data. For the purposes of this tutorial, you can select **Yes**, although you might skip this for commercial applications.

12. Click **Next** to generate MySQL compatible DDL code and then click **Finish** to exit the wizard.

You have seen how to create MySQL DDL code from an Entity Framework model.

6.6 Tutorial: Basic CRUD Operations with Connector/NET

This tutorial provides instructions to get you started using MySQL as a document store with MySQL Connector/NET.

- Minimum Requirements
- Import the Document Store Sample
- Add References to Required DLLs
- Import Namespaces
- Create a Session
- Find a Row Within a Collection
- Insert a New Document into a Collection
- Update an Existing Document
- Delete a Specific Document
- Close the Session
- Complete Code Example

For concepts and additional usage examples, see X DevAPI User Guide.

Minimum Requirements

- MySQL Server 8.0.11 with X Protocol enabled
- Connector/NET 8.0.11
- Visual Studio 2013/2015/2017
- `world_x` database sample

Import the Document Store Sample

A MySQL script is provided with data and a JSON collection. The sample contains the following:

- Collection
  - countryinfo: Information about countries in the world.
- Tables
  - country: Minimal information about countries of the world.

- city: Information about some of the cities in those countries.
- countrylanguage: Languages spoken in each country.

To install the `world_x` database sample, follow these steps:

1. Download `world_x.zip` from http://dev.mysql.com/doc/index-other.html.
2. Extract the installation archive to a temporary location such as `/tmp/`.

   Unpacking the archive results in two files, one of them named `world_x.sql`.
3. Connect to the MySQL server using the MySQL Client with the following command:

   ```
   $> mysql -u root -p
   ```

   Enter your password when prompted. A non-root account can be used as long as the account has privileges to create new databases. For more information about using the MySQL Client, see mysql — The MySQL Command-Line Client.
4. Execute the `world_x.sql` script to create the database structure and insert the data as follows:

   ```
   mysql> SOURCE /temp/world_x.sql;
   ```

   Replace `/temp/` with the path to the `world_x.sql` file on your system.

Add References to Required DLLs

Create a new Visual Studio Console Project targeting .NET Framework 4.6.2 (or later), .NET Core 1.1, or .NET Core 2.0. The code examples in this tutorial are shown in the C# language, but you can use any .NET language.

Add a reference in your project to the following DLLs:

- `MySql.Data.dll`
- `Google.Protobuf.dll`

Import Namespaces

Import the required namespaces by adding the following statements:

```
using MySqlX.XDevAPI;
using MySqlX.XDevAPI.Common;
using MySqlX.XDevAPI.CRUD;
```

Create a Session

A session in the X DevAPI is a high-level database session concept that is different from working with traditional low-level MySQL connections. It is important to understand that this session is not the same as a traditional MySQL session. Sessions encapsulate one or more actual MySQL connections.

The following example opens a session, which you can use later to retrieve a schema and perform basic CRUD operations.

```
string schemaName = "world_x";
// Define the connection string
```

```
string connectionURI = "mysqlx://test:test@localhost:33060";
Session session = MySQLX.GetSession(connectionURI);
// Get the schema object
Schema schema = session.GetSchema(schemaName);
```

Find a Row Within a Collection

After the session is instantiated, you can execute a find operation. The next example uses the session object that you created:

```
// Use the collection 'countryinfo'
var myCollection = schema.GetCollection("countryinfo");
var docParams = new DbDoc(new { name1 = "Albania", _id1 = "ALB" });

// Find a document
DocResult foundDocs = myCollection.Find("Name = :name1 || _id = :_id1").Bind(docParams).Execute();

while (foundDocs.Next())
{
 Console.WriteLine(foundDocs.Current["Name"]);
 Console.WriteLine(foundDocs.Current["_id"]);
}
```

Insert a New Document into a Collection

```
//Insert a new document with an identifier
var obj = new { _id = "UKN", Name = "Unknown" };
Result r = myCollection.Add(obj).Execute();
```

Update an Existing Document

```
// using the same docParams object previously created
docParams = new DbDoc(new { name1 = "Unknown", _id1 = "UKN" });
r = myCollection.Modify("_id = :Id").Bind("id", "UKN").Set("GNP", "3308").Execute();
if (r.AffectedItemsCount == 1)
{
  foundDocs = myCollection.Find("Name = :name1|| _id = :_id1").Bind(docParams).Execute();
  while (foundDocs.Next())
  {
     Console.WriteLine(foundDocs.Current["Name"]);
     Console.WriteLine(foundDocs.Current["_id"]);
     Console.WriteLine(foundDocs.Current["GNP"]);
  }
}
```

Delete a Specific Document

```
r = myCollection.Remove("_id = :id").Bind("id", "UKN").Execute();
```

Close the Session

```
session.Close();
```

Complete Code Example

The following example shows the basic operations that you can perform with a collection.

```
using MySqlX.XDevAPI;
using MySqlX.XDevAPI.Common;
using MySqlX.XDevAPI.CRUD;
using System;
```

```
namespace MySQLX_Tutorial
{
  class Program
  {
    static void Main(string[] args)
    {

      string schemaName = "world_x";
      string connectionURI = "mysqlx://test:test@localhost:33060";
      Session session = MySQLX.GetSession(connectionURI);
      Schema schema = session.GetSchema(schemaName);

      // Use the collection 'countryinfo'
      var myCollection = schema.GetCollection("countryinfo");
      var docParams = new DbDoc(new { name1 = "Albania", _id1 = "ALB" });

      // Find a document
      DocResult foundDocs = myCollection.Find("Name = :name1 || _id = :_id1").Bind(docParams).Execute();

      while (foundDocs.Next())
      {
        Console.WriteLine(foundDocs.Current["Name"]);
        Console.WriteLine(foundDocs.Current["_id"]);
      }

      //Insert a new document with an id
      var obj = new { _id = "UKN", Name = "Unknown" };
      Result r = myCollection.Add(obj).Execute();

      //update an existing document
      docParams = new DbDoc(new { name1 = "Unknown", _id1 = "UKN" });
      r = myCollection.Modify("_id = :Id").Bind("id", "UKN").Set("GNP", "3308").Execute();
      if (r.AffectedItemsCount == 1)
      {
        foundDocs = myCollection.Find("Name = :name1|| _id = :_id1").Bind(docParams).Execute();
        while (foundDocs.Next())
        {
          Console.WriteLine(foundDocs.Current["Name"]);
          Console.WriteLine(foundDocs.Current["_id"]);
          Console.WriteLine(foundDocs.Current["GNP"]);
        }
      }

      // delete a row in a document
      r = myCollection.Remove("_id = :id").Bind("id", "UKN").Execute();

      //close the session
      session.Close();

      Console.ReadKey();

    }
  }
}
```

6.7 Tutorial: Configuring SSL with Connector/NET

In this tutorial you will learn how you can use MySQL Connector/NET to connect to a MySQL server configured to use SSL. Support for SSL client PFX certificates was added to the Connector/NET 6.2 release series. PFX is the native format of certificates on Microsoft Windows. More recently, support for SSL client PEM certificates was added in the Connector/NET 8.0.16 release.

MySQL Server uses the PEM format for certificates and private keys. Connector/NET enables the use of either PEM or PFX certificates with both classic MySQL protocol and X Protocol. This tutorial uses the test

certificates from the server test suite by way of example. You can obtain the MySQL Server source code from MySQL Downloads. The certificates can be found in the `./mysql-test/std_data` directory.

To apply the server-side startup configuration for SSL connections:

1. In the MySQL Server configuration file, set the SSL parameters as shown in the follow PEM format example. Adjust the directory paths according to the location in which you installed the MySQL source code.

   ```
   ssl-ca=path/to/repo/mysql-test/std_data/cacert.pem
   ssl-cert=path/to/repo/mysql-test/std_data/server-cert.pem
   ssl-key=path/to/repo/mysql-test/std_data/server-key.pem
   ```

   The `SslCa` connection option accepts both PEM and PFX format certificates, using the file extension to determine how to process certificates. Change `cacert.pem` to `cacert.pfx` if you intend to continue with the PFX portion of this tutorial.

   For a description of the connection string options used in this tutorial, see Section 4.5, “Connector/NET Connection Options Reference”.

2. Create a test user account to use in this tutorial and set the account to require SSL. Using the MySQL Command-Line Client, connect as `root` and create the user `sslclient` (with `test` as the account password). Then, grant all privileges to the new user account as follows:

   ```
   CREATE USER sslclient@'%' IDENTIFIED BY 'test' REQUIRE SSL;

   GRANT ALL PRIVILEGES ON *.* TO sslclient@'%';
   ```

   For detailed information about account-management strategies, see Access Control and Account Management.

Now that the server-side configuration is finished, you can begin the client-side configuration using either PEM or PFX format certificates in Connector/NET.

6.7.1 Using PEM Certificates in Connector/NET

The direct use of PEM format certificates was introduced to simplify certificate management in multiplatform environments that include similar MySQL products. In previous versions of Connector/NET, your only choice was to use platform-dependent PFX format certificates.

For this example, use the test client certificates from the MySQL server repository (*`server-repository-root`*`/mysql-test/std_data`). In your application, add a connection string using the `test` database and the `sslclient` user account (created previously). For example:

1. Set the `SslMode` connection option to the level of security needed. PEM certificates are only validated for `VerifyCA` and `VerifyFull` SSL mode values. All other mode values ignore certificates even if they are provided.

   ```
   using (MySqlConnection connection = new MySqlConnection(
   "database=test;user=sslclient;" +
   "SslMode=VerifyFull"
   ```

2. Add the appropriate SSL certificates. Because this tutorial sets the `SslMode` option to `VerifyFull`, you must also provide values for the `SslCa`, `SslCert`, and `SslKey` connection options. Each option must point to a file with the `.pem` file extension.

   ```
   "SslCa=ca.pem;" +
   "SslCert=client-cert.pem;" +
   ```

```
"SslKey=client-key.pem;"))
```

Alternatively, if you set the SSL mode to `VerifyCA`, only the `SslCa` connection option is required.

3. Open a connection. The following example opens a connection using the classic MySQL protocol, but you can perform a similar test using X Protocol.

```
using (MySqlConnection connection = new MySqlConnection(
"database=test;user=sslclient;" +
  "SslMode=VerifyFull" +
  "SslCa=ca.pem;" +
  "SslCert=client-cert.pem;" +
  "SslKey=client-key.pem;"))

{
    connection.Open();
}
```

Errors found when processing the PEM certificates will result in an exception being thrown. For additional information, see Command Options for Encrypted Connections.

6.7.2 Using PFX Certificates in Connector/NET

.NET does not provide native support the PEM format. Instead, Windows includes a certificate store that provides platform-dependent certificates in PFX format. For the purposes of this example, use test client certificates from the MySQL server repository (`./mysql-test/std_data`). Convert these to PFX format first. This format is also known as PKCS#12.

To complete the steps in this tutorial for PFX certificates, you must have Open SSL installed. This can be downloaded for Microsoft Windows at no charge from Shining Light Productions.

Creating a Certificate File to Use with the .NET Client

1. From the directory *`server-repository-root`*`/mysql-test/std_data`, issue the following command.

```
openssl pkcs12 -export -in client-cert.pem -inkey client-key.pem -certfile cacert.pem -out client.pfx
```

2. When asked for an export password, enter the password “pass”. The file `client.pfx` will be generated. This file is used in the remainder of the tutorial.

Connecting to the Server Using a File-Based Certificate

1. Use the `client.pfx` file that you created in the previous step to authenticate the client. The following example demonstrates how to connect using the `SslMode`, `CertificateFile`, and `CertificatePassword` connection string options.

```
using (MySqlConnection connection = new MySqlConnection(
  "database=test;user=sslclient;" +
  "CertificateFile=H:\\git\\mysql-trunk\\mysql-test\\std_data\\client.pfx;" +
  "CertificatePassword=pass;" +
  "SslMode=Required "))

{
    connection.Open();
}
```

The path to the certificate file needs to be changed to reflect your individual installation. When using PFX format certificates, the `SslMode` connection option validates certificates for all SSL mode values, except `Disabled` or `None` (deprecated in Connector/NET 8.0.29).

Connecting to the Server Using a Store-Based Certificate

1. The first step is to import the PFX file, `client.pfx`, into the Personal Store. Double-click the file in Windows explorer. This launches the Certificate Import Wizard.
2. Follow the steps dictated by the wizard, and when prompted for the password for the PFX file, enter “pass”.
3. Click **Finish** to close the wizard and import the certificate into the personal store.

Examining Certificates in the Personal Store

1. Start the Microsoft Management Console by entering `mmc.exe` at a command prompt.
2. Select **Add/Remove snap-in** from the **File** menu. Click **Add**. Select **Certificates** from the list of available snap-ins.
3. In the dialog, click **Add** and then select the **My user account** option. This option is used for personal certificates.
4. Click **Finish**.
5. Click **OK** to close the Add/Remove Snap-in dialog.
6. You now have **Certificates – Current User** displayed in the left panel of the Microsoft Management Console. Expand the Certificates - Current User tree item and select **Personal**, **Certificates**. The right panel displays a certificate issued to MySQL that was previously imported. Double-click the certificate to display its details.
7. After you have imported the certificate to the Personal Store, you can use a more succinct connection string to connect to the database, as illustrated by the following code:

```
using (MySqlConnection connection = new MySqlConnection(
   "database=test;user=sslclient;" +
   "Certificate Store Location=CurrentUser;" +
   "SslMode=Required"))

{
   connection.Open();
}
```

Certificate Thumbprint Parameter

If you have a large number of certificates in your store, and many have the same Issuer, this can be a source of confusion and result in the wrong certificate being used. To alleviate this situation, there is an optional Certificate Thumbprint parameter that can additionally be specified as part of the connection string. As mentioned before, you can double-click a certificate in the Microsoft Management Console to display the certificate's details. When the Certificate dialog is displayed click the **Details** tab and scroll down to see the thumbprint. The thumbprint will typically be a number such as `#47 94 36 00 9a 40 f3 01 7a 14 5c f8 47 9e 76 94 d7 aa de f0`. This thumbprint can be used in the connection string, as the following code illustrates:

```
using (MySqlConnection connection = new MySqlConnection(
      "database=test;user=sslclient;" +
      "Certificate Store Location=CurrentUser;" +
      "Certificate Thumbprint=479436009a40f3017a145cf8479e7694d7aadef0;"+
      "SSL Mode=Required"))
{
    connection.Open();
}
```

Spaces in the thumbprint parameter are optional and the value is not case-sensitive.

6.8 Tutorial: Using MySqlScript

This tutorial teaches you how to use the `MySqlScript` class. This class enables you to execute a series of statements. Depending on the circumstances, this can be more convenient than using the `MySqlCommand` approach.

Further details of the `MySqlScript` class can be found in the reference documentation supplied with MySQL Connector/NET.

To run the example programs in this tutorial, set up a simple test database and table using the `mysql` Command-Line Client or MySQL Workbench. Commands for the `mysql` Command-Line Client are given here:

```
CREATE DATABASE TestDB;
USE TestDB;
CREATE TABLE TestTable (id INT NOT NULL PRIMARY KEY
  AUTO_INCREMENT, name VARCHAR(100));
```

The main method of the `MySqlScript` class is the `Execute` method. This method causes the script (sequence of statements) assigned to the Query property of the MySqlScript object to be executed. The Query property can be set through the `MySqlScript` constructor or by using the Query property. `Execute` returns the number of statements executed.

The `MySqlScript` object will execute the specified script on the connection set using the Connection property. Again, this property can be set directly or through the `MySqlScript` constructor. The following code snippets illustrate this:

```
string sql = "SELECT * FROM TestTable";
...
MySqlScript script = new MySqlScript(conn, sql);
...
MySqlScript script = new MySqlScript();
script.Query = sql;
script.Connection = conn;
...
script.Execute();
```

The MySqlScript class has several events associated with it. There are:

1. Error - generated if an error occurs.
2. ScriptCompleted - generated when the script successfully completes execution.
3. StatementExecuted - generated after each statement is executed.

It is possible to assign event handlers to each of these events. These user-provided routines are called back when the connected event occurs. The following code shows how the event handlers are set up.

```
script.Error += new MySqlScriptErrorEventHandler(script_Error);
script.ScriptCompleted += new EventHandler(script_ScriptCompleted);
script.StatementExecuted += new MySqlStatementExecutedEventHandler(script_StatementExecuted);
```

In VisualStudio, you can save typing by using tab completion to fill out stub routines. Start by typing, for example, “script.Error +=”. Then press **TAB**, and then press **TAB** again. The assignment is completed, and a stub event handler created. A complete working example is shown below:

```
using System;
using System.Collections.Generic;
using System.Linq;
```

```
using System.Text;

using System.Data;
using MySql.Data;
using MySql.Data.MySqlClient;

namespace MySqlScriptTest
{
    class Program
    {
        static void Main(string[] args)
        {
            string connStr = "server=localhost;user=root;database=TestDB;port=3306;password=******";
            MySqlConnection conn = new MySqlConnection(connStr);

            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();

                string sql = "INSERT INTO TestTable(name) VALUES ('Superman');" +
                             "INSERT INTO TestTable(name) VALUES ('Batman');" +
                             "INSERT INTO TestTable(name) VALUES ('Wolverine');" +
                             "INSERT INTO TestTable(name) VALUES ('Storm');";

                MySqlScript script = new MySqlScript(conn, sql);

                script.Error += new MySqlScriptErrorEventHandler(script_Error);
                script.ScriptCompleted += new EventHandler(script_ScriptCompleted);
                script.StatementExecuted += new MySqlStatementExecutedEventHandler(script_StatementExecuted);

                int count = script.Execute();

                Console.WriteLine("Executed " + count + " statement(s).");
                Console.WriteLine("Delimiter: " + script.Delimiter);
            }
            catch (Exception ex)
            {
                Console.WriteLine(ex.ToString());
            }

            conn.Close();
            Console.WriteLine("Done.");
        }

        static void script_StatementExecuted(object sender, MySqlScriptEventArgs args)
        {
            Console.WriteLine("script_StatementExecuted");
        }

        static void script_ScriptCompleted(object sender, EventArgs e)
        {
            /// EventArgs e will be EventArgs.Empty for this method
            Console.WriteLine("script_ScriptCompleted!");
        }

        static void script_Error(Object sender, MySqlScriptErrorEventArgs args)
        {
            Console.WriteLine("script_Error: " + args.Exception.ToString());
        }
    }
}
```

In the `script_ScriptCompleted` event handler, the `EventArgs` parameter `e` will be `EventArgs.Empty`. In the case of the `ScriptCompleted` event there is no additional data to be obtained, which is why the event object is `EventArgs.Empty`.

Using Delimiters with MySqlScript

Depending on the nature of the script, you may need control of the delimiter used to separate the statements that will make up a script. The most common example of this is where you have a multi-statement stored routine as part of your script. In this case if the default delimiter of ";" is used you will get an error when you attempt to execute the script. For example, consider the following stored routine:

```
CREATE PROCEDURE test_routine()
BEGIN
    SELECT name FROM TestTable ORDER BY name;
    SELECT COUNT(name) FROM TestTable;
END
```

This routine actually needs to be executed on the MySQL Server as a single statement. However, with the default delimiter of ";", the `MySqlScript` class would interpret the above as two statements, the first being:

```
CREATE PROCEDURE test_routine()
BEGIN
    SELECT name FROM TestTable ORDER BY name;
```

Executing this as a statement would generate an error. To solve this problem `MySqlScript` supports the ability to set a different delimiter. This is achieved through the Delimiter property. For example, you could set the delimiter to "??", in which case the above stored routine would no longer generate an error when executed. Multiple statements can be delimited in the script, so for example, you could have a three statement script such as:

```
string sql = "DROP PROCEDURE IF EXISTS test_routine??" +
             "CREATE PROCEDURE test_routine() " +
             "BEGIN " +
             "SELECT name FROM TestTable ORDER BY name;" +
             "SELECT COUNT(name) FROM TestTable;" +
             "END??" +
             "CALL test_routine()";
```

You can change the delimiter back at any point by setting the Delimiter property. The following code shows a complete working example:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;

using MySql.Data;
using MySql.Data.MySqlClient;

namespace ConsoleApplication8
{
    class Program
    {
        static void Main(string[] args)
        {
            string connStr = "server=localhost;user=root;database=TestDB;port=3306;password=******";
            MySqlConnection conn = new MySqlConnection(connStr);

            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();

                string sql =    "DROP PROCEDURE IF EXISTS test_routine??" +
                                "CREATE PROCEDURE test_routine() " +
                                "BEGIN " +
```

```
                                "SELECT name FROM TestTable ORDER BY name;" +
                                "SELECT COUNT(name) FROM TestTable;" +
                                "END??" +
                                "CALL test_routine()";

                MySqlScript script = new MySqlScript(conn);

                script.Query = sql;
                script.Delimiter = "??";
                int count = script.Execute();
                Console.WriteLine("Executed " + count + " statement(s)");
                script.Delimiter = ";";
                Console.WriteLine("Delimiter: " + script.Delimiter);
                Console.WriteLine("Query: " + script.Query);
            }
            catch (Exception ex)
            {
                Console.WriteLine(ex.ToString());
            }

            conn.Close();
            Console.WriteLine("Done.");
        }
    }
}
```

Chapter 7 Connector/NET for Entity Framework

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Entity Framework is the name given to a set of technologies that support the development of data-oriented software applications. MySQL Connector/NET supports Entity Framework 6.0 (EF6 or EF 6.4) and Entity Framework Core (EF Core), which is the most recent framework available to .NET developers who work with MySQL data using .NET objects.

The following table identifies each Entity Framework release and shows which Connector/NET 8.1 series supports the release. Backward compatibility of each feature set is determined by the framework rather than by Connector/NET.

Table 7.1 Entity Framework Support by Connector/NET Version

Framework Type	Connector/NET Support
EF Core	• EF Core 7.0: Full support with 8.1.0 and later on platforms that support .NET 7. • EF Core 7.0: Full support with 8.0.33 and later on platforms that support .NET 7. • EF Core 6.0: Full support with 8.0.28 and later on platforms that support .NET 6.
EF6 | EF 6.4	• EF 6.4: Full cross-platform support in 8.0.22 and later. • EF6: Full support on Windows only in 8.0.11 and later.

7.1 Entity Framework 6 Support

MySQL Connector/NET integrates support for Entity Framework 6 (EF6), which now includes support for cross-platform application deployment with the EF 6.4 version. This chapter describes how to configure and use the EF6 features that are implemented in Connector/NET.

In this section:

- Minimum Requirements for EF6 on Windows Only
- Minimum Requirements for EF 6.4 with Cross-Platform Support
- Configuration
- EF6 Features

- Code First Features
- Example for Using EF6

Minimum Requirements for EF6 on Windows Only

- Connector/NET 6.10 or 8.0.11
- MySQL Server 5.6
- Entity Framework 6 assemblies
- .NET Framework 4.6.2

Minimum Requirements for EF 6.4 with Cross-Platform Support

- Connector/NET 8.0.22
- MySQL Server 5.6
- Entity Framework 6.4 assemblies
- .NET Standard 2.1 (.NET Core SDK 3.1 and Visual Studio 2019 version 16.5)

Configuration

> **Note**
>
> The MySQL Connector/NET 8.0 release series has a naming scheme for EF6 assemblies and NuGet packages that differs from the scheme used with previous release series, such as 6.9 and 6.10. To configure Connector/NET 6.9 or 6.10 for use with EF6, substitute the assembly and package names in this section with the following:
>
> - Assembly: `MySql.Data.Entity.EF6`
> - NuGet package: `MySql.Data.Entity`
>
>   For more information about the `MySql.Data.Entity` NuGet package and its uses, see https://www.nuget.org/packages/MySql.Data.Entity/.

To configure Connector/NET support for EF6:

1. Edit the configuration sections in the `app.config` file to add the connection string and the Connector/NET provider.

```
<connectionStrings>
    <add name="MyContext" providerName="MySql.Data.MySqlClient"
        connectionString="server=localhost;port=3306;database=mycontext;uid=root;password=********"/>
</connectionStrings>
<entityFramework>
    <defaultConnectionFactory type="System.Data.Entity.Infrastructure.SqlConnectionFactory, EntityFramework
    <providers>
        <provider invariantName="MySql.Data.MySqlClient"
            type="MySql.Data.MySqlClient.MySqlProviderServices, MySql.Data.EntityFramework"/>
        <provider invariantName="System.Data.SqlClient"
            type="System.Data.Entity.SqlServer.SqlProviderServices, EntityFramework.SqlServer"/>
    </providers>
```

```
</entityFramework>
```

2. Apply the assembly reference using one of the following techniques:

   - **NuGet package.** Install the NuGet package to add this reference automatically to the `app.config` or `web.config` file during the installation. For example, to install the package for Connector/NET 8.0.22, use one of the following installation options:

     - Command Line Interface (CLI)

       ```
       dotnet add package MySql.Data.EntityFramework -Version 8.0.22
       ```

     - Package Manager Console (PMC)

       ```
       Install-Package MySql.Data.EntityFramework -Version 8.0.22
       ```

     - Visual Studio with NuGet Package Manager. For this option, select `nuget.org` as the package source, search for `mysql.data`, and install a stable version of `MySql.Data.EntityFramework`.

   - **MySQL Connector/NET MSI file.** Install MySQL Connector/NET and then add a reference for the `MySql.Data.EntityFramework` assembly to your project. Depending on the .NET Framework version used, the assembly is taken from the `v4.0`, `v4.5`, or `v4.8` folder.

   - **MySQL Connector/NET source code.** Build Connector/NET from source and then insert the following data provider information into the `app.config` or `web.config` file:

     ```
     <system.data>
        <DbProviderFactories>
          <remove invariant="MySql.Data.MySqlClient" />
          <add name="MySQL Data Provider" invariant="MySql.Data.MySqlClient" description=".Net Framework D
               type="MySql.Data.MySqlClient.MySqlClientFactory, MySql.Data, Version=8.0.22.0, Culture=neut
        </DbProviderFactories>
     </system.data>
     ```

     > **Important**
     >
     > Always update the version number to match the one in the `MySql.Data.dll` assembly.

3. Set the new `DbConfiguration` class for MySQL. This step is optional but highly recommended, because it adds all the dependency resolvers for MySQL classes. This can be done in three ways:

   - Adding the `DbConfigurationTypeAttribute` on the context class:

     ```
     [DbConfigurationType(typeof(MySqlEFConfiguration))]
     ```

   - Calling `DbConfiguration.SetConfiguration(new MySqlEFConfiguration())` at the application start up.

   - Set the `DbConfiguration` type in the configuration file:

     ```
     <entityFramework codeConfigurationType="MySql.Data.Entity.MySqlEFConfiguration, MySql.Data.EntityFram
     ```

   It is also possible to create a custom `DbConfiguration` class and add the dependency resolvers needed.

EF6 Features

Following are the new features in Entity Framework 6 implemented in Connector/NET:

- *Cross-platform support* in Connector/NET 8.0.22 implements EF 6.4 as the initial provider version to include Linux and macOS compatibility with .NET Standard 2.1 from Microsoft.
- *Async Query and Save* adds support for the task-based asynchronous patterns that have been available since .NET 4.5. The new asynchronous methods supported by Connector/NET are:
  - `ExecuteNonQueryAsync`
  - `ExecuteScalarAsync`
  - `PrepareAsync`
- *Connection Resiliency / Retry Logic* enables automatic recovery from transient connection failures. To use this feature, add to the `OnCreateModel` method:

```
SetExecutionStrategy(MySqlProviderInvariantName.ProviderName, () => new MySqlExecutionStrategy());
```

- *Code-Based Configuration* gives you the option of performing configuration in code, instead of performing it in a configuration file, as it has been done traditionally.
- *Dependency Resolution* introduces support for the Service Locator. Some pieces of functionality that can be replaced with custom implementations have been factored out. To add a dependency resolver, use:

```
AddDependencyResolver(new MySqlDependencyResolver());
```

  The following resolvers can be added:

  - `DbProviderFactory -> MySqlClientFactory`
  - `IDbConnectionFactory -> MySqlConnectionFactory`
  - `MigrationSqlGenerator -> MySqlMigrationSqlGenerator`
  - `DbProviderServices -> MySqlProviderServices`
  - `IProviderInvariantName -> MySqlProviderInvariantName`
  - `IDbProviderFactoryResolver -> MySqlProviderFactoryResolver`
  - `IManifestTokenResolver -> MySqlManifestTokenResolver`
  - `IDbModelCacheKey -> MySqlModelCacheKeyFactory`
  - `IDbExecutionStrategy -> MySqlExecutionStrategy`
- *Interception/SQL logging* provides low-level building blocks for interception of Entity Framework operations with simple SQL logging built on top:

```
myContext.Database.Log = delegate(string message) { Console.Write(message); };
```

- *DbContext can now be created with a DbConnection that is already opened*, which enables scenarios where it would be helpful if the connection could be open when creating the context (such as sharing a connection between components when you cannot guarantee the state of the connection)

```
  [DbConfigurationType(typeof(MySqlEFConfiguration))]
  class JourneyContext : DbContext
  {
    public DbSet<MyPlace> MyPlaces { get; set; }

    public JourneyContext()
```

```
      : base()
    {

    }

    public JourneyContext(DbConnection existingConnection, bool contextOwnsConnection)
      : base(existingConnection, contextOwnsConnection)
    {

    }
  }

  using (MySqlConnection conn = new MySqlConnection("<connectionString>"))
  {
    conn.Open();
    ...

    using (var context = new JourneyContext(conn, false))
    {
      ...
    }
  }
```

- *Improved Transaction Support* provides support for a transaction external to the framework as well as improved ways of creating a transaction within the Entity Framework. Starting with Entity Framework 6, `Database.ExecuteSqlCommand()` will wrap by default the command in a transaction if one was not already present. There are overloads of this method that allow users to override this behavior if wished. Execution of stored procedures included in the model through APIs such as `ObjectContext.ExecuteFunction()` does the same. It is also possible to pass an existing transaction to the context.
- *DbSet.AddRange/RemoveRange* provides an optimized way to add or remove multiple entities from a set.

Code First Features

Following are new Code First features supported by Connector/NET:

- *Code First Mapping to Insert/Update/Delete Stored Procedures* supported:

```
modelBuilder.Entity<EntityType>().MapToStoredProcedures();
```

- *Idempotent migrations scripts* allow you to generate an SQL script that can upgrade a database at any version up to the latest version. To do so, run the **`Update-Database -Script -SourceMigration: $InitialDatabase`** command in Package Manager Console.
- *Configurable Migrations History Table* allows you to customize the definition of the migrations history table.

Example for Using EF6

The following C# code example represents the structure of an Entity Framework 6 model.

```
using MySql.Data.Entity;
using System.Data.Common;
using System.Data.Entity;

namespace EF6
{
  // Code-Based Configuration and Dependency resolution
  [DbConfigurationType(typeof(MySqlEFConfiguration))]
  public class Parking : DbContext
```

```
  {
    public DbSet<Car> Cars { get; set; }

    public Parking()
      : base()
    {

    }

    // Constructor to use on a DbConnection that is already opened
    public Parking(DbConnection existingConnection, bool contextOwnsConnection)
      : base(existingConnection, contextOwnsConnection)
    {

    }

    protected override void OnModelCreating(DbModelBuilder modelBuilder)
    {
      base.OnModelCreating(modelBuilder);
      modelBuilder.Entity<Car>().MapToStoredProcedures();
    }
  }

  public class Car
  {
    public int CarId { get; set; }

    public string Model { get; set; }

    public int Year { get; set; }

    public string Manufacturer { get; set; }
  }
}
```

The C# code example that follows shows how to use the entities from the previous model in an application that stores the data within a MySQL table.

```
using MySql.Data.MySqlClient;
using System;
using System.Collections.Generic;

namespace EF6
{
  class Example
  {
    public static void ExecuteExample()
    {
      string connectionString = "server=localhost;port=3305;database=parking;uid=root";

      using (MySqlConnection connection = new MySqlConnection(connectionString))
      {
        // Create database if not exists
        using (Parking contextDB = new Parking(connection, false))
        {
          contextDB.Database.CreateIfNotExists();
        }

        connection.Open();
        MySqlTransaction transaction = connection.BeginTransaction();

        try
        {
          // DbConnection that is already opened
          using (Parking context = new Parking(connection, false))
          {
```

```
            // Interception/SQL logging
            context.Database.Log = (string message) => { Console.WriteLine(message); };

            // Passing an existing transaction to the context
            context.Database.UseTransaction(transaction);

            // DbSet.AddRange
            List<Car> cars = new List<Car>();

            cars.Add(new Car { Manufacturer = "Nissan", Model = "370Z", Year = 2012 });
            cars.Add(new Car { Manufacturer = "Ford", Model = "Mustang", Year = 2013 });
            cars.Add(new Car { Manufacturer = "Chevrolet", Model = "Camaro", Year = 2012 });
            cars.Add(new Car { Manufacturer = "Dodge", Model = "Charger", Year = 2013 });

            context.Cars.AddRange(cars);

            context.SaveChanges();
          }

          transaction.Commit();
        }
        catch
        {
          transaction.Rollback();
          throw;
        }
      }
    }
  }
}
```

7.2 Entity Framework Core Support

MySQL Connector/NET integrates support for Entity Framework Core (EF Core). The requirements and configuration of EF Core depend on the version of Connector/NET installed and the features that you require. Use the table that follows to evaluate the minimum requirements.

Table 7.2 Connector/NET Versions and Entity Framework Core Support

Connector/NET	EF Core 7.0	EF Core 6.0
8.1.0	.NET 7	.NET 6
8.0.33	.NET 7	.NET 6
8.0.28	Not supported	.NET 6
8.0.23 to 8.0.27	Not supported	EF Core 6.0 preview

In this section:

- General Requirements for EF Core Support
- Configuration with MySQL
- Limitations
- Maximum String Length

General Requirements for EF Core Support

- Connector/NET 8.1
- Server version: MySQL 8.1, MySQL 8.0, or MySQL 5.7

- Entity Framework Core packages (replace *n* with a valid number to complete the full version of the package):
  - `MySql.EntityFrameworkCore` 7.0.*n*+MySQL8.1.*n* (Connector/NET 8.1.0 and later)
  - `MySql.EntityFrameworkCore` 6.0.*n*+MySQL8.1.*n* (Connector/NET 8.1.0 and later)
- An implementation of .NET Standard or .NET Framework that is supported by Connector/NET (see Table 7.2, “Connector/NET Versions and Entity Framework Core Support”)
- .NET | .NET Core SDK
  - **.NET 7.0 for all supported platforms:** https://dotnet.microsoft.com/download/dotnet/7.0
  - **.NET 6.0 for all supported platforms:** https://dotnet.microsoft.com/download/dotnet/6.0
  - **.NET Core for Microsoft Windows:** https://www.microsoft.com/net/core#windowscmd
  - **.NET Core for Linux:** https://www.microsoft.com/net/core#linuxredhat
  - **.NET Core for macOS:** https://www.microsoft.com/net/core#macos
  - **Docker:** https://www.microsoft.com/net/core#dockercmd
- Optional: Microsoft Visual Studio 2017, 2019, 2022, or Code

> **Note**
>
> For the minimum version of Visual Studio to use with Connector/NET, see Table 2.1, “Connector/NET Requirements for Related Products”.

Configuration with MySQL

To use Entity Framework Core with a MySQL database, do the following:

1. Install the NuGet package.

   When you install either the `MySql.EntityFrameworkCore` or `MySql.Data.EntityFrameworkCore` package, all of the related packages required to run your application are installed for you. For instructions on adding a NuGet package, see the relevant Microsoft documentation.

2. In the class that derives from the `DbContext` class, override the `OnConfiguring` method to set the MySQL data provider with `UseMySQL`. The following example shows how to set the provider using a generic connection string in C#.

```
protected override void OnConfiguring(DbContextOptionsBuilder optionsBuilder)
{
     #warning To protect potentially sensitive information in your connection string,
     you should move it out of source code. See http://go.microsoft.com/fwlink/?LinkId=723263
     for guidance on storing connection strings.

   optionsBuilder.UseMySQL("server=localhost;database=library;user=user;password=password");
}
```

Limitations

The Connector/NET implementation of EF Core has the following limitations:

- Memory-Optimized Tables is not supported.

Maximum String Length

The following table shows the maximum length of string types supported by the Connector/NET implementation of EF Core. Length values are in bytes for nonbinary and binary string types, depending on the character set used.

Table 7.3 Maximum Length of strings used with Entity Framework Core

Data Type	Maximum Length	.NET Type
`CHAR`	255	`string`
`BINARY`	255	`byte[]`
`VARCHAR`, `VARBINARY`	65,535	`string`, `byte[]`
`TINYBLOB`, `TINYTEXT`	255	`byte[]`
`BLOB`, `TEXT`	65,535	`byte[]`
`MEDIUMBLOB`, `MEDIUMTEXT`	16,777,215	`byte[]`
`LONGBLOB`, `LONGTEXT`	4,294,967,295	`byte[]`
`ENUM`	65,535	`string`
`SET`	65,535	`string`

For additional information about the storage requirements of the string types, see String Type Storage Requirements.

7.2.1 Creating a Database with Code First in EF Core

The Code First approach enables you to define an entity model in code, create a database from the model, and then add data to the database. MySQL Connector/NET is compatible with multiple versions of Entity Framework Core. For specific compatibility information, see Table 7.2, “Connector/NET Versions and Entity Framework Core Support”.

The following example shows the process of creating a database from existing code. Although this example uses the C# language, you can use any .NET language and run the resulting application on Windows, macOS, or Linux.

1. Create a console application for this example.

   a. Initialize a valid .NET Core project and console application using the .NET Core command-line interface (CLI) and then switch to the newly created folder (`mysqlefcore`).

   ```
   dotnet new console –o mysqlefcore
   ```

   ```
   cd mysqlefcore
   ```

   b. Add the `MySql.EntityFrameworkCore` package to the application by using the dotnet CLI or the **Package Manager Console** in Visual Studio.

dotnet CLI

Enter the following command to add the MySQL EF Core 7.0 package for use with Connector/NET 8.0.33 and later.

```
dotnet add package MySql.EntityFrameworkCore --version 7.0.2
```

Package Manager Console

Enter the following command to add the MySQL EF Core 7.0 package for use with Connector/NET 8.0.33 and later.

```
Install-Package MySql.EntityFrameworkCore -Version 7.0.2
```

c. Restore dependencies and project-specific tools that are specified in the project file as follows:

```
dotnet restore
```

2. Create the model and run the application.

The model in this example is to be used by the console application. It consists of two entities related to a book library that are configured in the `LibraryContext` class (or database context).

a. Create a new file named `LibraryModel.cs` and then add the following `Book` and `Publisher` classes to the `mysqlefcore` namespace.

```
namespace mysqlefcore
{
  public class Book
  {
    public string ISBN { get; set; }
    public string Title { get; set; }
    public string Author { get; set; }
    public string Language { get; set; }
    public int Pages { get; set; }
    public virtual Publisher Publisher { get; set; }
  }

  public class Publisher
  {
    public int ID { get; set; }
    public string Name { get; set; }
    public virtual ICollection<Book> Books { get; set; }
  }
}
```

b. Create a new file named `LibraryContext.cs` and add the code that follows. Replace the generic connection string with one that is appropriate for your MySQL server configuration.

> **Note**
>
> The `MySQL.EntityFrameworkCore.Extensions` namespace applies to Connector/NET 8.0.23 and later. Earlier connector versions require the `MySQL.Data.EntityFrameworkCore.Extensions` namespace.

```
using Microsoft.EntityFrameworkCore;
using MySQL.EntityFrameworkCore.Extensions;

namespace mysqlefcore
{
  public class LibraryContext : DbContext
  {
    public DbSet<Book> Book { get; set; }

    public DbSet<Publisher> Publisher { get; set; }

    protected override void OnConfiguring(DbContextOptionsBuilder optionsBuilder)
    {
      optionsBuilder.UseMySQL("server=localhost;database=library;user=user;password=password");
```

```
    }

    protected override void OnModelCreating(ModelBuilder modelBuilder)
    {
      base.OnModelCreating(modelBuilder);

      modelBuilder.Entity<Publisher>(entity =>
      {
        entity.HasKey(e => e.ID);
        entity.Property(e => e.Name).IsRequired();
      });

      modelBuilder.Entity<Book>(entity =>
      {
        entity.HasKey(e => e.ISBN);
        entity.Property(e => e.Title).IsRequired();
        entity.HasOne(d => d.Publisher)
          .WithMany(p => p.Books);
      });
    }
  }
}
```

The `LibraryContex` class contains the entities to use and it enables the configuration of specific attributes of the model, such as `Key`, required columns, references, and so on.

c. Insert the following code into the existing `Program.cs` file, replacing the default C# code.

```
using Microsoft.EntityFrameworkCore;
using System;
using System.Text;

namespace mysqlefcore
{
  class Program
  {
    static void Main(string[] args)
    {
      InsertData();
      PrintData();
    }

    private static void InsertData()
    {
      using(var context = new LibraryContext())
      {
        // Creates the database if not exists
        context.Database.EnsureCreated();

        // Adds a publisher
        var publisher = new Publisher
        {
          Name = "Mariner Books"
        };
        context.Publisher.Add(publisher);

        // Adds some books
        context.Book.Add(new Book
        {
          ISBN = "978-0544003415",
          Title = "The Lord of the Rings",
          Author = "J.R.R. Tolkien",
          Language = "English",
          Pages = 1216,
          Publisher = publisher
        });
```

```
        context.Book.Add(new Book
        {
          ISBN = "978-0547247762",
          Title = "The Sealed Letter",
          Author = "Emma Donoghue",
          Language = "English",
          Pages = 416,
          Publisher = publisher
        });

        // Saves changes
        context.SaveChanges();
      }
    }

    private static void PrintData()
    {
      // Gets and prints all books in database
      using (var context = new LibraryContext())
      {
        var books = context.Book
          .Include(p => p.Publisher);
        foreach(var book in books)
        {
          var data = new StringBuilder();
          data.AppendLine($"ISBN: {book.ISBN}");
          data.AppendLine($"Title: {book.Title}");
          data.AppendLine($"Publisher: {book.Publisher.Name}");
          Console.WriteLine(data.ToString());
        }
      }
    }
  }
}
```

d. Use the following CLI commands to restore the dependencies and then run the application.

```
dotnet restore
```

```
dotnet run
```

The output from running the application is represented by the following example:

```
ISBN: 978-0544003415
Title: The Lord of the Rings
Publisher: Mariner Books

ISBN: 978-0547247762
Title: The Sealed Letter
Publisher: Mariner Books
```

7.2.2 Scaffolding an Existing Database in EF Core

Scaffolding a database produces an Entity Framework model from an existing database. The resulting entities are created and mapped to the tables in the specified database. For an overview of the requirements to use EF Core with MySQL, see Table 7.2, “Connector/NET Versions and Entity Framework Core Support”).

NuGet packages have the ability to select the best target for a project, which means that NuGet installs the libraries related to that specific framework version.

There are two different ways to scaffold an existing database:

- Scaffolding a Database Using .NET Core CLI

- Scaffolding a Database Using Package Manager Console in Visual Studio

This section shows how to scaffold the `sakila` database using both approaches. Additional scaffolding techniques are:

- Scaffolding a Database by Filtering Tables
- Scaffolding with Multiple Schemas

Requirements

For the components needed to reproduce each scaffolding approach, see General Requirements for EF Core Support. With the Package Manager Console approach, determine which version of Visual Studio is recommended for the version of .NET or .NET Core in use (see Table 2.1, “Connector/NET Requirements for Related Products”).

To download `sakila` database, see https://dev.mysql.com/doc/sakila/en/.

> **Note**
>
> When upgrading ASP.NET Core applications to a newer framework, be sure to use the appropriate EF Core version (see https://docs.microsoft.com/en-us/aspnet/core/migration/30-to-31?view=aspnetcore-3.1).

Scaffolding a Database Using .NET Core CLI

1. Initialize a valid .NET Core project and console application using the .NET Core command-line interface (CLI) and then change to the newly created folder (`sakilaConsole`).

```
dotnet new console –o sakilaConsole
```

```
cd sakilaConsole
```

2. Add the MySQL NuGet package for EF Core using the CLI. For example, use the following command to add the MySQL EF Core 7.0 package for use with Connector/NET 8.0.33 and later.

```
dotnet add package MySql.EntityFrameworkCore --version 7.0.2
```

3. Add the following `Microsoft.EntityFrameworkCore.Design` Nuget package:

```
dotnet add package Microsoft.EntityFrameworkCore.Tools
```

4. Restore dependencies and project-specific tools that are specified in the project file as follows:

```
dotnet restore
```

5. Create the Entity Framework Core model by executing the following command. The connection string for this example must include `database=sakila`. For information about using connection strings, see Section 4.1, “Creating a Connector/NET Connection String”.

   > **Note**
   >
   > If you are using a connector version earlier than Connector/NET 8.0.23, replace `MySql.EntityFrameworkCore` with `MySql.Data.EntityFrameworkCore`.

```
dotnet ef dbcontext scaffold "connection-string" MySql.EntityFrameworkCore -o sakila -f
```

To validate that the model has been created, open the new `sakila` folder. You should see files corresponding to all tables mapped to entities. In addition, look for the `sakilaContext.cs` file, which contains the `DbContext` for this database.

Scaffolding a Database Using Package Manager Console in Visual Studio

1. Open Visual Studio and create a new **Console App (.NET Core)** for C#.
2. Add the MySQL NuGet package for EF Core using the **Package Manager Console**. For example, use the following command to add the MySQL EF Core 7.0 package for use the Connector/NET 8.0.33 and later.

```
Install-Package MySql.EntityFrameworkCore -Version 7.0.2
```

3. Install the following NuGet package by selecting either **Package Manager Console** (or **Manage NuGet Packages for Solution** and then **NuGet Package Manager**) from the **Tools** menu: `Microsoft.EntityFrameworkCore.Tools`.
4. Open **Package Manager Console** and enter the following command at the prompt to create the entities and `DbContext` for the `sakila` database. The connection string for this example must include `database=sakila`. For information about using connection strings, see Section 4.1, “Creating a Connector/NET Connection String”.

> **Note**
>
> If you are using a connector version earlier than Connector/NET 8.0.23, replace `MySql.EntityFrameworkCore` with `MySql.Data.EntityFrameworkCore`.

```
Scaffold-DbContext "connection-string" MySql.EntityFrameworkCore -OutputDir sakila -f
```

Visual Studio creates a new `sakila` folder inside the project, which contains all the tables mapped to entities and the `sakilaContext.cs` file.

Scaffolding a Database by Filtering Tables

It is possible to specify the exact tables in a schema to use when scaffolding database and to omit the rest. The command-line examples that follow show the parameters needed for filtering tables. The connection string for this example must include `database=sakila`.

If you are using a connector version earlier than Connector/NET 8.0.23, replace `MySql.EntityFrameworkCore` with `MySql.Data.EntityFrameworkCore`.

.NET Core CLI:

```
dotnet ef dbcontext scaffold "connection-string" MySql.EntityFrameworkCore -o sakila -t actor -t film -t film_
```

Package Manager Console in Visual Studio:

```
Scaffold-DbContext "connection-string" MySql.EntityFrameworkCore -OutputDir Sakila -Tables actor,film,language
```

Scaffolding with Multiple Schemas

When scaffolding a database, you can use more than one schema or database. Note that the account used to connect to the MySQL server must have access to each schema to be included within the context.

The following command-line examples show how to incorporate the `sakila` and `world` schemas within a single context. If you are using a connector version earlier than Connector/NET 8.0.23, replace `MySql.EntityFrameworkCore` with `MySql.Data.EntityFrameworkCore`.

.NET Core CLI:

```
dotnet ef dbcontext scaffold "connection-string" MySql.EntityFrameworkCore -o sakila --schema sakila --sch
```

Package Manager Console in Visual Studio:

```
Scaffold-DbContext "connection-string" MySql.EntityFrameworkCore -OutputDir Sakila -Schemas sakila,world -
```

7.2.3 Configuring Character Sets and Collations in EF Core

This section describes how to change the character set, collation, or both at the entity and entity-property level in an Entity Framework (EF) Core model. Modifications made to the model affect the tables and columns generated from your code.

There are two distinct approaches available for configuring character sets and collations in code-first scenarios. Data annotation enables you to apply attributes directly to your EF Core model. Alternatively, you can override the `OnModelCreating` method on your derived `DbContext` class and use the code-first fluent API to configure specific characteristics of the model. An example of each approach follows.

For more information about supported character sets and collations, see Character Sets and Collations in MySQL.

Using Data Annotation

Before you can annotate an EF Core model with character set and collation attributes, add a reference to the following namespace in the file that contains your entity model.

> **Note**
>
> The `MySQL.EntityFrameworkCore.DataAnnotations` namespace applies to Connector/NET 8.0.23 and later. Earlier connector versions require the `MySQL.Data.EntityFrameworkCore.DataAnnotations` namespace.

```
using MySql.EntityFrameworkCore.DataAnnotations;
```

Add one or more `[MySqlCharset]` attributes to store data using a variety of character sets and one or more `[MySqlCollation]` attributes to perform comparisons according to a variety of collations. In the following example, the `ComplexKey` class represents an entity (or table) and `Key1`, `Key2`, and `CollationColumn` represent entity properties (or columns).

```
[MySqlCharset("utf8")]
public class ComplexKey
{
  [MySqlCharset("latin1")
  public string Key1 { get; set; }

  [MySqlCharset("latin1")]
  public string Key2 { get; set; }

  [MySqlCollation("latin1_spanish_ci")]
  public string CollationColumn { get; set; }
}
```

Using the Code-First Fluent API

Add the following directive to reference the methods related to character set and collation configuration.

> **Note**
>
> The `MySQL.EntityFrameworkCore.Extensions` namespace applies to Connector/NET 8.0.23 and later. Earlier connector versions require the `MySQL.Data.EntityFrameworkCore.Extensions` namespace.

```
using MySQL.EntityFrameworkCore.Extensions;
```

When using the fluent API approach, the EF Core model remains unchanged. Fluent API overrides any rule set by an attribute.

```
public class ComplexKey
{
  public string Key1 { get; set; }

  public string Key2 { get; set; }

  public string CollationColumn { get; set; }
}
```

In this example, the entity and various entity properties are reconfigured, including the conventional mappings to character sets and collations. This approach uses the `ForMySQLHasCharset` and `ForMySQLHasCollation` methods.

```
public class MyContext : DbContext
{
  public DbSet<ComplexKey> ComplexKeys { get; set; }

  protected override void OnModelCreating(ModelBuilder modelBuilder)
  {
    modelBuilder.Entity<ComplexKey>(e =>
    {
      e.HasKey(p => new { p.Key1, p.Key2 });
      e.ForMySQLHasCollation("ascii_bin"); // defining collation at Entity level
      e.Property(p => p.Key1).ForMySQLHasCharset("latin1"); // defining charset in a property
      e.Property(p => p.CollationColumnFA).ForMySQLHasCollation("utf8_bin"); // defining collation in a proper
    });
  }
}
```

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This chapter provides a high-level reference to the ADO.NET and .NET Core components that are implemented in the most recent version of Connector/NET. For a complete API listing, visit MySQL Documentation to locate the Connector/NET 8.0 API reference guide that is generated from embedded documentation.

8.1 MySql.Data.Common.DnsClient

Enumerations

Enumeration	Description
`OPCode`	DNS Record OpCode. A four bit field that specifies kind of query in this message. This value is set by the originator of a query and copied into the response.

8.2 MySql.Data.MySqlClient Namespace

Classes

Class	Description
`AuthenticationPluginConfigurationElement`	Retrieves the authentication plugin configuration from the configuration file.
`BaseCommandInterceptor`	Provides a means of enhancing or replacing SQL commands through the connection string rather than recompiling.
`BaseTableCache`	Provides a base class used for the table cache.
`CharacterSet`	Specifies a character set.
`GenericConfigurationElementCollection<T>`	Retrieves an element collection from the configuration file.
`InterceptorConfigurationElement`	Class used in the configuration file to get configuration details for interceptors.
`MySqlAttribute`	Represents a query attribute to a MySqlCommand.

Class	Description
MySqlAttributeCollection	Represents a collection of query attributes relevant to a MySqlCommand.
MySqlBaseConnectionStringBuilder	Abstract class that provides common functionality for connection options that apply for all protocols.
MySqlBulkLoader	Load many rows into the database.
MySqlClientFactory	Represents the DBProviderFactory implementation for MySqlClient.
MySqlClientPermission	Derived from the .NET DBDataPermission class. For usage information, see Section 5.7, "Working with Partial Trust / Medium Trust".
MySqlClientPermissionAttribute	Associates a security action with a custom security attribute.
MySqlCommand	Represents an SQL statement to execute against a MySQL database. This class cannot be inherited.
MySqlCommandBuilder	Automatically generates single-table commands used to reconcile changes made to a data set with the associated MySQL database. This class cannot be inherited.
MySqlConfiguration	Defines a configuration section that contains the information specific to MySQL.
MySqlConnection	Represents an open connection to a MySQL Server database. This class cannot be inherited.
MySqlConnectionStringBuilder	Defines all of the connection string options that can be used.
MySqlDataAdapter	Represents a set of data commands and a database connection that are used to fill a data set and update a MySQL database. This class cannot be inherited.
MySqlDataReader	Provides a means of reading a forward-only stream of rows from a MySQL database. This class cannot be inherited.
MySqlError	Collection of error codes that can be returned by the server
MySqlException	The exception that is thrown when MySQL returns an error. This class cannot be inherited.
MySqlHelper	Helper class that makes it easier to work with the provider.
MySqlInfoMessageEventArgs	Provides data for the InfoMessage event. This class cannot be inherited.
MySqlParameter	Represents a parameter to a MySql.Data.MySqlClient.MySqlCommand, and optionally, its mapping to columns in a dataset. This class cannot be inherited.
MySqlParameterCollection	Represents a collection of parameters relevant to a MySql.Data.MySqlClient.MySqlCommand as

Class	Description
	well as their respective mappings to columns in a dataset. This class cannot be inherited.
MySqlRowUpdatedEventArgs	Provides data for the RowUpdated event. This class cannot be inherited.
MySqlRowUpdatingEventArgs	Provides data for the RowUpdating event. This class cannot be inherited.
MySqlSchemaCollection	Contains information about a schema.
MySqlSchemaRow	Represents a row within a schema.
MySqlScript	Provides a class capable of executing an SQL script containing multiple SQL statements including CREATE PROCEDURE statements that require changing the delimiter.
MySqlScriptErrorEventArgs	Provides an error event argument used in MySqlScript.
MySqlScriptEventArgs	Provides an event argument used in MySqlScript.
MySqlSecurityPermission	Creates permission sets.
MySqlTrace	Logs events in a defined listener.
MySqlTransaction	Represents an SQL transaction to be made in a MySQL database. This class cannot be inherited.
ReplicationConfigurationElement	Defines a replication configuration element in the configuration file.
ReplicationServerConfigurationElement	Defines a replication server in the configuration file.
ReplicationServerGroupConfigurationElement	Defines a replication server group in the configuration file
SchemaColumn	Represents a column object within a schema.

Delegates

Delegate	Description
FidoActionCallback	Represents the method to handle the FidoActionRequested event of a MySqlConnection.
MySqlInfoMessageEventHandler	Represents the method to handle the InfoMessage event of a MySqlConnection.
MySqlRowUpdatedEventHandler	Represents the method to handle the RowUpdatedevent of a MySqlDataAdapter.
MySqlRowUpdatingEventHandler	Represents the method to handle the RowUpdatingevent of a MySqlDataAdapter.
MySqlScriptErrorEventHandler	Represents the method to handle an error in MySqlScript.
MySqlStatementExecutedEventHandler	Represents the method to be called after the execution of a statement in MySqlScript.

Enumerations

Enumeration	Description
`CloseNotification`	The warnings that cause a connection to close.
`CompressionAlgorithms`	Defines the compression algorithms that can be used.
`CompressionType`	Defines the type of compression used when data is exchanged between client and server.
`KerberosAuthMode`	Defines the different modes that can be used for Kerberos authentication.
`LockContention`	Defines waiting options that may be used with row locking options.
`MySqlAuthenticationMode`	Specifies the authentication mechanism that should be used.
`MySqlBulkLoaderConflictOption`	Defines the action to perform when a conflict is found.
`MySqlBulkLoaderPriority`	Defines the load priority.
`MySqlCertificateStoreLocation`	Defines the certificate store location.
`MySqlConnectionProtocol`	Specifies the type of connection to use.
`MySqlDbType`	Specifies the MySQL data type of a field or property for use in a `MySql.Data.MySqlClient.MySqlParameter`.
`MySqlDriverType`	Specifies the connection types that are supported.
`MySqlErrorCode`	Provides a reference to error codes returned by MySQL.
`MySQLGuidFormat`	Specifies the stored type for a MySQL GUID data type.
`MySqlSslMode`	Provides the SSL options for a connection.
`MySqlTraceEventType`	Defines the log event type in MySqlTrace.
`UsageAdvisorWarningFlags`	Defines the usage advisor warning type.

8.3 MySql.Data.MySqlClient.Authentication Namespace

Classes

Class	Description
`MySqlAuthenticationPlugin`	Abstract class used to define an authentication plugin.
`MySqlClearPasswordPlugin`	Allows connections to a user account set with the `mysql_clear_password` authentication plugin.
`MySqlNativePasswordPlugin`	Implements the `mysql_native_password` authentication plugin.
`MySqlPemReader`	Provides functionality to read, decode, and convert PEM files into objects supported in .NET.

8.4 MySql.Data.MySqlClient.Interceptors Namespace

Classes

Class	Description
`BaseExceptionInterceptor`	Represents the base class for all user-defined exception interceptors.

8.5 MySql.Data.MySqlClient.Replication Namespace

The `MySql.Data.MySqlClient.Replication` namespace contains members for replication and load-balancing components.

Classes

Class	Description
`ReplicationRoundRobinServerGroup`	Class that implements round-robin load balancing.
`ReplicationServer`	Represents a server in the replication environment.
`ReplicationServerGroup`	Base class used to implement load-balancing features.

8.6 MySql.Data.Types Namespace

The `MySql.Data.Types` namespace contains members for converting MySQL types.

Classes

Class	Description
`MySqlConversionException`	Represents exceptions returned during the conversion of MySQL types.

Structures

Structure	Description
`MySqlDateTime`	Defines operations that apply to `MySqlDateTime` objects.
`MySqlDecimal`	Defines operations that apply to `MySqlDecimal` objects.
`MySqlGeometry`	Defines operations that apply to `MySqlGeometry` objects.

8.7 MySql.Data.EntityFramework Namespace

Classes

Class	Description
`BackoffAlgorithm`	Represents the base class for backoff algorithms.

Class	Description
BackoffAlgorithmErr1040	Backoff algorithm customized for the MySQL error code 1040 - Too many connections.
BackoffAlgorithmErr1205	Backoff algorithm customized for the MySQL error code 1205 - Lock wait timeout exceeded; try restarting transaction.
BackoffAlgorithmErr1213	Backoff algorithm customized for MySQL error code 1213 - Deadlock found when trying to get lock; try restarting transaction.
BackoffAlgorithmErr1614	Backoff algorithm for the MySQL error code 1614 - Transaction branch was rolled back: deadlock was detected.
BackoffAlgorithmErr2006	Backoff algorithm customized for MySQL error code 2006 - MySQL server has gone away.
BackoffAlgorithmErr2013	Backoff algorithm customized for MySQL error code 2013 - Lost connection to MySQL server during query.
BackoffAlgorithmNdb	Backoff algorithm customized for MySQL Cluster (NDB) errors.
MySqlConnectionFactory	Used for creating connections in Code First 4.3.
MySqlDependencyResolver	Class used to resolve implementation of services.
MySqlEFConfiguration	Class used to define the MySQL services used in Entity Framework.
MySqlExecutionStrategy	Provided an execution strategy tailored for handling MySQL server transient errors.
MySqlHistoryContext	Class used by code first migrations to read and write migration history from the database.
MySqlLogger	Provides the logger class for use with Entity Framework.
MySqlManifestTokenResolver	Represents a service for getting a provider manifest token given a connection.
MySqlMigrationCodeGenerator	Class used to customized code generation to avoid the `dbo.` prefix added on table names.
MySqlMigrationSqlGenerator	Implements the MySQL SQL generator for EF 4.3 data migrations.
MySqlModelCacheKey	Represents a key value that uniquely identifies an Entity Framework model that has been loaded into memory.
MySqlProviderFactoryResolver	Represents a service for obtaining the correct MySQL `DbProviderFactory` from a connection.
MySqlProviderInvariantName	Defines the MySQL provider name.

Enumerations

Enumeration	Description
OpType	Represents a set of database operations.

8.8 Microsoft.EntityFrameworkCore Namespace

Enables access to .NET Core command-line interface (CLI) tools.

Classes

Class	Description
`MySQLDbContextOptionsExtensions`	Represents the context-option extensions implemented for MySQL.

8.9 MySql.EntityFrameworkCore Namespace

Namespaces in this section:

- MySql.EntityFrameworkCore.DataAnnotations Namespace
- MySQL.EntityFrameworkCore.Diagnostics Namespace
- MySql.EntityFrameworkCore.Extensions Namespace
- MySql.EntityFrameworkCore.Infrastructure Namespace
- MySql.EntityFrameworkCore.Infrastructure.Internal Namespace
- MySql.EntityFrameworkCore.Metadata Namespace
- MySql.EntityFrameworkCore.Migrations.Operations Namespace
- MySql.EntityFrameworkCore.Query Namespace

MySql.EntityFrameworkCore.DataAnnotations Namespace

Classes

Class	Description
`MySqlCharsetAttribute`	Establishes the character set of an entity property.
`MySqlCollationAttribute`	Sets the collation in an entity property.

MySQL.EntityFrameworkCore.Diagnostics Namespace

Classes

Class	Description
`MySQLEventId`	Event IDs for MySQL events that correspond to messages logged to an `ILogger` and events sent to a `DiagnosticSource`. The IDs are also used with `WarningsConfigurationBuilder` to configure the behavior of warnings.

MySql.EntityFrameworkCore.Extensions Namespace

Classes

Class	Description
`MySQLDatabaseFacadeExtensions`	MySQL specific extension methods for `Database()`.
`MySQLDbFunctionsExtensions`	Provides CLR methods that get translated to database functions when used in LINQ to Entities queries. The methods on this class are accessed via `Functions()`.
`MySQLEntityTypeExtensions`	MySQL specific extension methods for entity types.
`MySqlIndexBuilderExtensions`	Inheritance
`MySQLIndexExtensions`	Extension methods for `IIndex` for SQL Server-specific metadata.
`MySQLKeyBuilderExtensions`	Inheritance
`MySQLKeyExtensions`	Extension methods for `IKey` for MySQL-specific metadata.
`MySQLMigrationBuilderExtensions`	MySQL specific extension methods for `MigrationBuilder`.
`MySQLModelBuilderExtensions`	Inheritance
`MySQLPropertyBuilderExtensions`	Represents the implementation of MySQL property-builder extensions used in Fluent API.
`MySQLPropertyExtensions`	Extension methods for `IProperty` for MySQL Server-specific metadata.
`MySQLServiceCollectionExtensions`	MySQL extension class for `IServiceCollection`.

Enumerations

Enumeration	Description
`MySQLMatchSearchMode`	Performs a search against a text collection.

MySql.EntityFrameworkCore.Infrastructure Namespace

Classes

Class	Description
`MySQLDbContextOptionsBuilder`	Represents the `RelationalDbContextOptionsBuilder` type implemented for MySQL.

Delegates

Delegate	Description
`MySQLSchemaNameTranslator`	Translates the specified schema and object to an output object name whenever a schema is being used.

Enumerations

Enumeration	Description
MySqlSchemaBehavior	Represents the behavior of the schema.

MySql.EntityFrameworkCore.Infrastructure.Internal Namespace

Classes

Class	Description
MySQLOptionsExtension	Represents the RelationalOptionsExtension type implemented for MySQL.

Interfaces

Interface	Description
IMySQLOptions	Represents options to set on the provider.

MySql.EntityFrameworkCore.Metadata Namespace

Enumerations

Enumeration	Description
MySQLValueGenerationStrategy	An internal enumeration that supports the Entity Framework Core infrastructure.

MySql.EntityFrameworkCore.Migrations.Operations Namespace

Classes

Class	Description
MySQLDropPrimaryKeyAndRecreateForeignKeyOperation	A migration operation for dropping a primary key and recreating foreign keys.
MySQLDropUniqueConstraintAndRecreateForeignKeyOperation	A migration operation for dropping a unique constraint and recreating foreign keys.

MySql.EntityFrameworkCore.Query Namespace

Classes

Class	Description
MySQLJsonString	Represents a string that contains valid JSON data. To mark a string as containing JSON data, just cast the string to MySQLJsonString.

8.10 MySql.Web Namespace

The MySql.Web namespace includes a set of subordinate namespaces that represent the features managed by various MySQL providers and available for use within ASP.NET applications.

Namespaces in this section:

- MySql.Web.Common Namespace
- MySql.Web.Personalization Namespace
- MySql.Web.Profile Namespace
- MySql.Web.Security Namespace
- MySql.Web.SessionState Namespace
- MySql.Web.SiteMap Namespace

MySql.Web.Common Namespace

Classes

Class	Description
SchemaManager	Manages schema-related operations.

MySql.Web.Personalization Namespace

Classes

Class	Description
MySqlPersonalizationProvider	Implements a personalization provider enabling the use of web parts at ASP.NET websites.

MySql.Web.Profile Namespace

Classes

Class	Description
MySQLProfileProvider	Implements a profile provider for the MySQL database.

MySql.Web.Security Namespace

Classes

Class	Description
MySQLMembershipProvider	Manages storage of membership information for an ASP.NET application in a MySQL database.
MySQLRoleProvider	Manages storage of role membership information for an ASP.NET application in a MySQL database.
MySqlSimpleMembershipProvider	Provides support for website membership tasks, such as creating accounts, deleting accounts, and managing passwords.
MySqlSimpleRoleProvider	Provides basic role-management functionality.

Class	Description
MySqlWebSecurity	Provides security and authentication features for ASP.NET Web Pages applications, including the ability to create user accounts, log users in and out, reset or change passwords, and perform related tasks.

MySql.Web.SessionState Namespace

Classes

Class	Description
MySqlSessionStateStore	Enables ASP.NET applications to store and manage session state information in a MySQL database. Expired session data is periodically deleted from the database.

MySql.Web.SiteMap Namespace

Classes

Class	Description
MySqlSiteMapProvider	Implements a site-map provider for the MySQL database.

Chapter 9 Connector/NET Support

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9.2 How to Report Connector/NET Problems or Bugs 163

The developers of MySQL Connector/NET greatly value the input of our users in the software development process. If you find Connector/NET lacking some feature important to you, or if you discover a bug and need to file a bug report, please use the instructions in How to Report Bugs or Problems.

9.1 Connector/NET Community Support

- Community support for MySQL Connector/NET can be found through the forums at http://forums.mysql.com.
- Paid support is available from Oracle. Additional information is available at http://dev.mysql.com/support/.

9.2 How to Report Connector/NET Problems or Bugs

If you encounter difficulties or problems with MySQL Connector/NET, contact the Connector/NET community, as explained in Section 9.1, “Connector/NET Community Support”.

First try to execute the same SQL statements and commands from the `mysql` client program. This helps you determine whether the error is in Connector/NET or MySQL.

If reporting a problem, ideally include the following information with the email:

- Operating system and version.
- Connector/NET version.
- MySQL server version.
- Copies of error messages or other unexpected output.
- Simple reproducible sample.

Remember that the more information you can supply to us, the more likely it is that we can fix the problem.

If you believe the problem to be a bug, then you must report the bug through http://bugs.mysql.com/.

Chapter 10 Connector/NET FAQ

Questions

- 10.1: Are all commands executed after a transaction begins automatically enlisted in the transaction?
- 10.2: How do I obtain the value of an auto-incremented column?

Questions and Answers

10.1: Are all commands executed after a transaction begins automatically enlisted in the transaction?

Yes. When a client begins a transaction in classic MySQL, all subsequent commands (on that connection) are part of that transaction until the client commits or rolls back the transaction. To execute a command outside of that transaction, you must open a separate connection.

10.2: How do I obtain the value of an auto-incremented column?

When using `CommandBuilder`, setting `ReturnGeneratedIdentifiers` property to `true` no longer works, as `CommandBuilder` does not add `last_insert_id()` by default.

CommandBuilder hooks up to the `DataAdapter.RowUpdating` event handler, which means it is called for every row. It examines the command object and, if it is the same referenced object, it essentially rebuilds the object, thereby destroying your command text changes.

One approach to solving this problem is to clone the command object so you have a different actual reference:

```
dataAdapter.InsertCommand = cb.GetInsertCommand().Clone()
```

This works, but since the CommandBuilder is still connected to the DataAdapter, the RowUpdating event still fires, adversely affecting performance. To stop that, once all your commands have been added you need to disconnect the CommandBuilder from the DataAdapter:

```
cb.DataAdapter = null;
```

The last requirement is to make sure the `id` that is returned by `last_insert_id()` has the correct name. For example:

```
SELECT last_insert_id() AS id
```

A complete working example is shown here:

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;

using System.Data;
using MySql.Data;
using MySql.Data.MySqlClient;

namespace GetAutoIncId
{
    class Program
    {
        static void Main(string[] args)
        {
            string connStr = "server=localhost;user=root;database=TestDB;port=3306;password=******;";
```

```
            MySqlConnection conn = new MySqlConnection(connStr);

            try
            {
                Console.WriteLine("Connecting to MySQL...");
                conn.Open();

                string sql = "SELECT * FROM TestTable";

                MySqlDataAdapter da = new MySqlDataAdapter(sql, conn);
                MySqlCommandBuilder cb = new MySqlCommandBuilder(da);

                MySqlCommand cmd = new MySqlCommand();
                cmd.Connection = conn;
                cmd.CommandText = sql;
                // use Cloned object to avoid .NET rebuilding the object, and
                // thereby throwing away our command text additions.
                MySqlCommand insertCmd = cb.GetInsertCommand().Clone();
                insertCmd.CommandText = insertCmd.CommandText + ";SELECT last_insert_id() AS id";
                insertCmd.UpdatedRowSource = UpdateRowSource.FirstReturnedRecord;
                da.InsertCommand = insertCmd;
                cb.DataAdapter = null; // Unhook RowUpdating event handler

                DataTable dt = new DataTable();
                da.Fill(dt);

                DataRow row = dt.NewRow();
                row["name"] = "Joe Smith";

                dt.Rows.Add(row);
                da.Update(dt);

                System.Console.WriteLine("ID after update: " + row["id"]);
            }
            catch (Exception ex)
            {
                Console.WriteLine(ex.ToString());
            }

            conn.Close();
            Console.WriteLine("Done.");
        }
    }
}
```