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Data Access with ADO.NET

Accessing SQL Server and MySQL from .NET and C#

Telerik Software Academy

Learning & Development Team

http://academy.telerik.com

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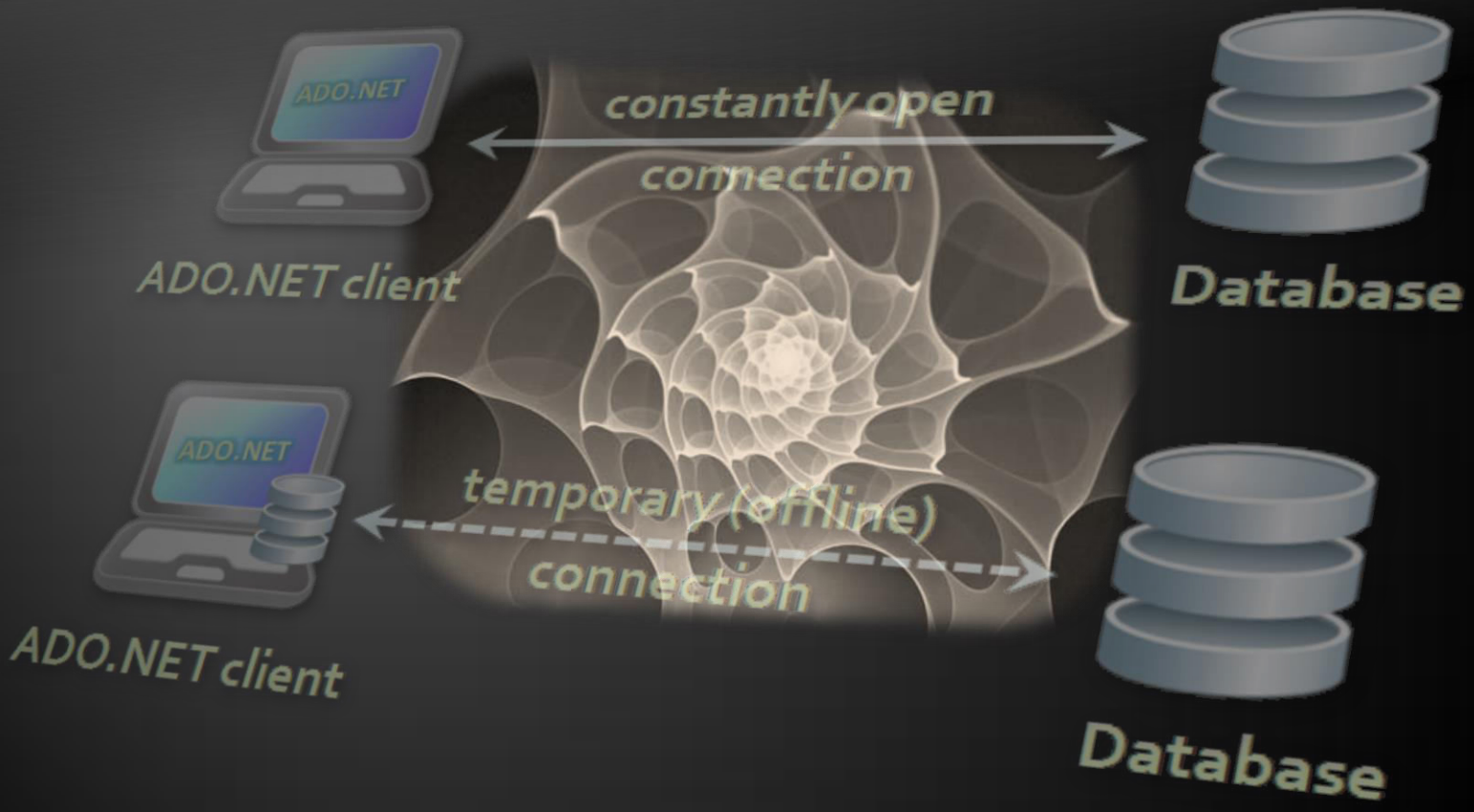
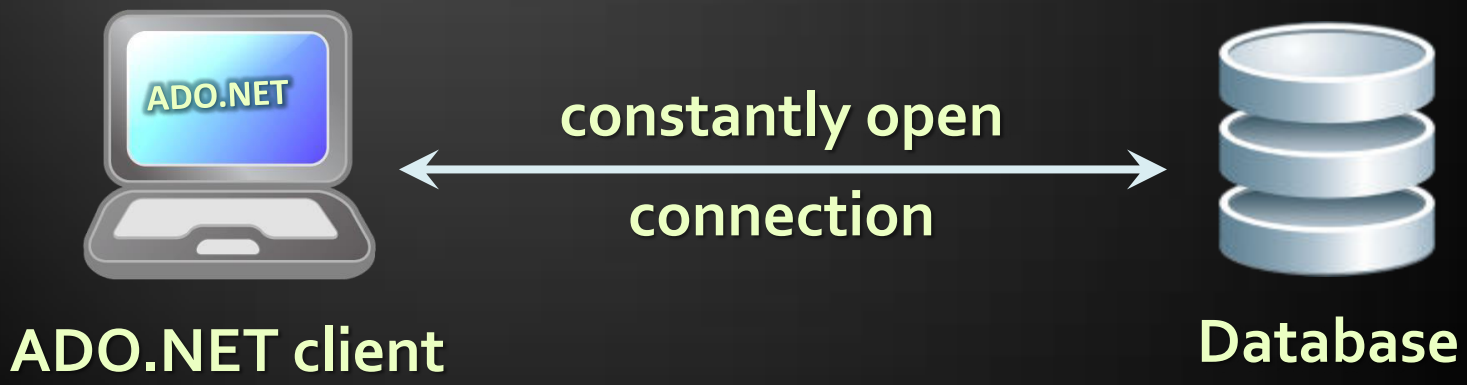


Data Access Models

Connected Model

- Connected data access model
  - Applicable to an environment where the database is constantly available

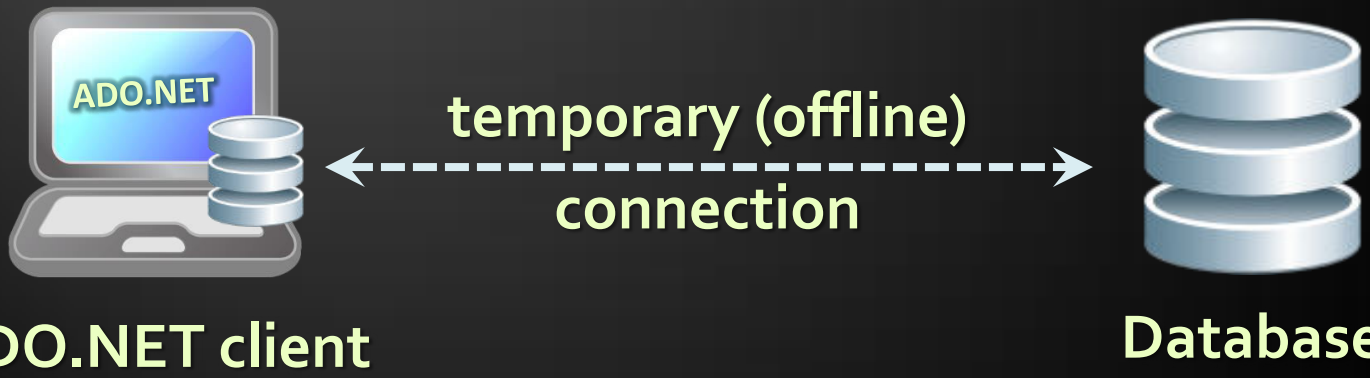


Connected Model: Benefits and Drawbacks

- Connected data access model (`SqlClient`)
  - Benefits:
    - Concurrency control is easier to maintain
    - Better chance to work with the most recent version of the data
  - Drawbacks:
    - Needs a constant reliable network
    - Problems when scalability is an issue

Disconnected Model

- Disconnected data access model (DataSet)
  - A subset of the central database is copied locally at the client and he works with the copy
  - Database synchronization is done offline



- Legacy technology (deprecated)

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Disconnected Model: Benefits and Drawbacks

- Benefits:
  - The client connects to DB from time to time
    - Works with the local copy the rest of the time
  - Other clients can connect during that time
  - Has superior scalability
- Drawbacks:
  - The data you work with is not always the latest data in the database
  - Additional efforts to resolve the conflicts caused by different versions of the data

ORM Model

- Object-Relational Mapping data access model (Entity Framework)
  - Maps database tables to classes and objects
  - Objects can be automatically persisted in the database
  - Can operate in both connected and disconnected models

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ORM Model – Benefits and Problems

- ORM model benefits
  - Increased productivity – writing less code
  - Use objects with associations instead of tables and SQL commands
  - Integrated object query mechanism
- ORM model drawbacks:
  - Less flexibility
    - SQL is automatically generated
  - Performance issues (sometimes)

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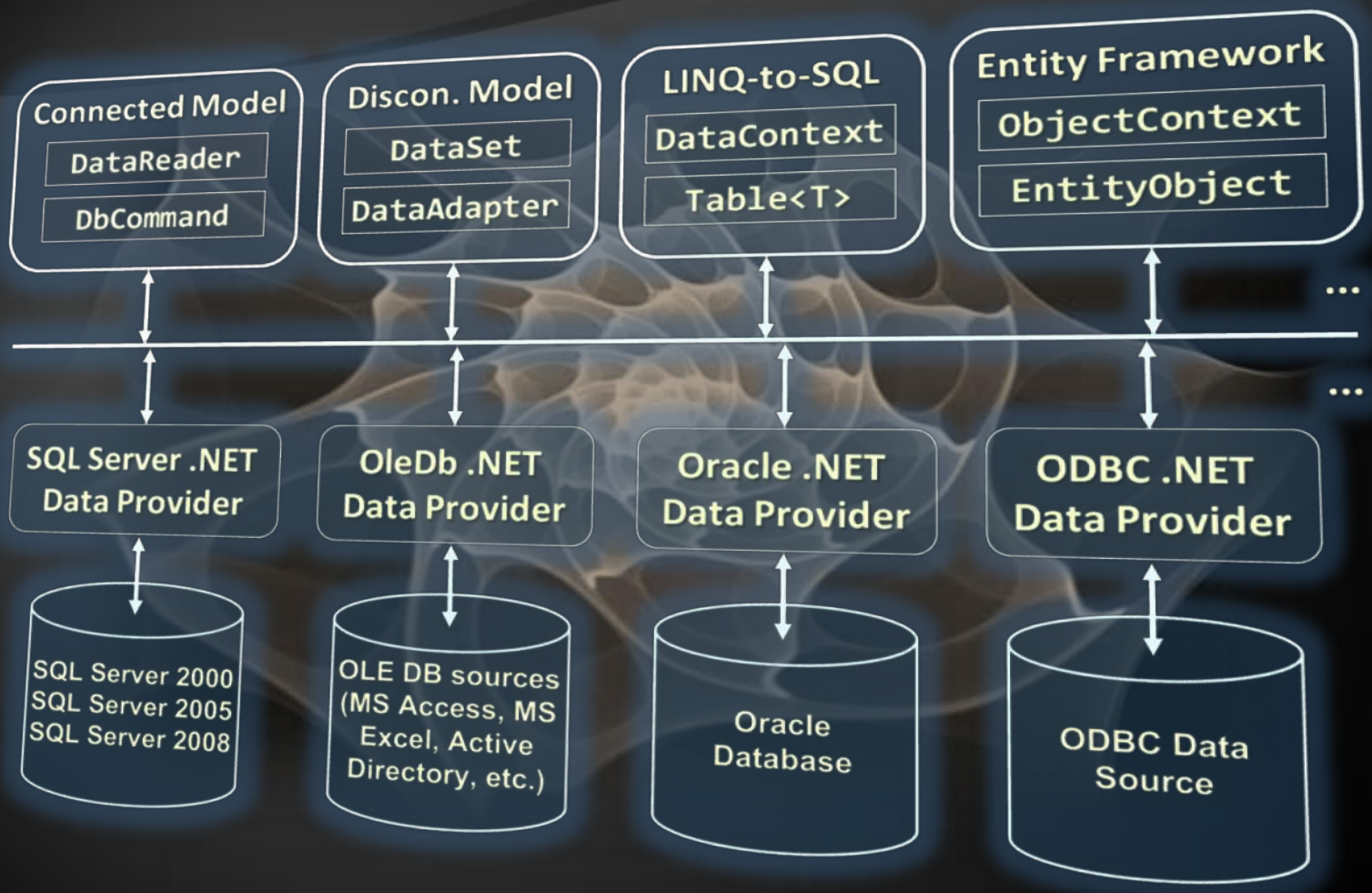

ADO.NET Architecture

What Is ADO.NET?

- ADO.NET is a standard .NET class library for accessing databases, processing data and XML
  - A program model for working with data in .NET
  - Supports connected, disconnected and ORM data access models
  - Excellent integration with LINQ, XML and WCF
  - Allows executing SQL in RDBMS systems
    - DB connections, data readers, DB commands
  - Allows accessing data in the ORM approach
    - LINQ-to-SQL and ADO.NET Entity Framework

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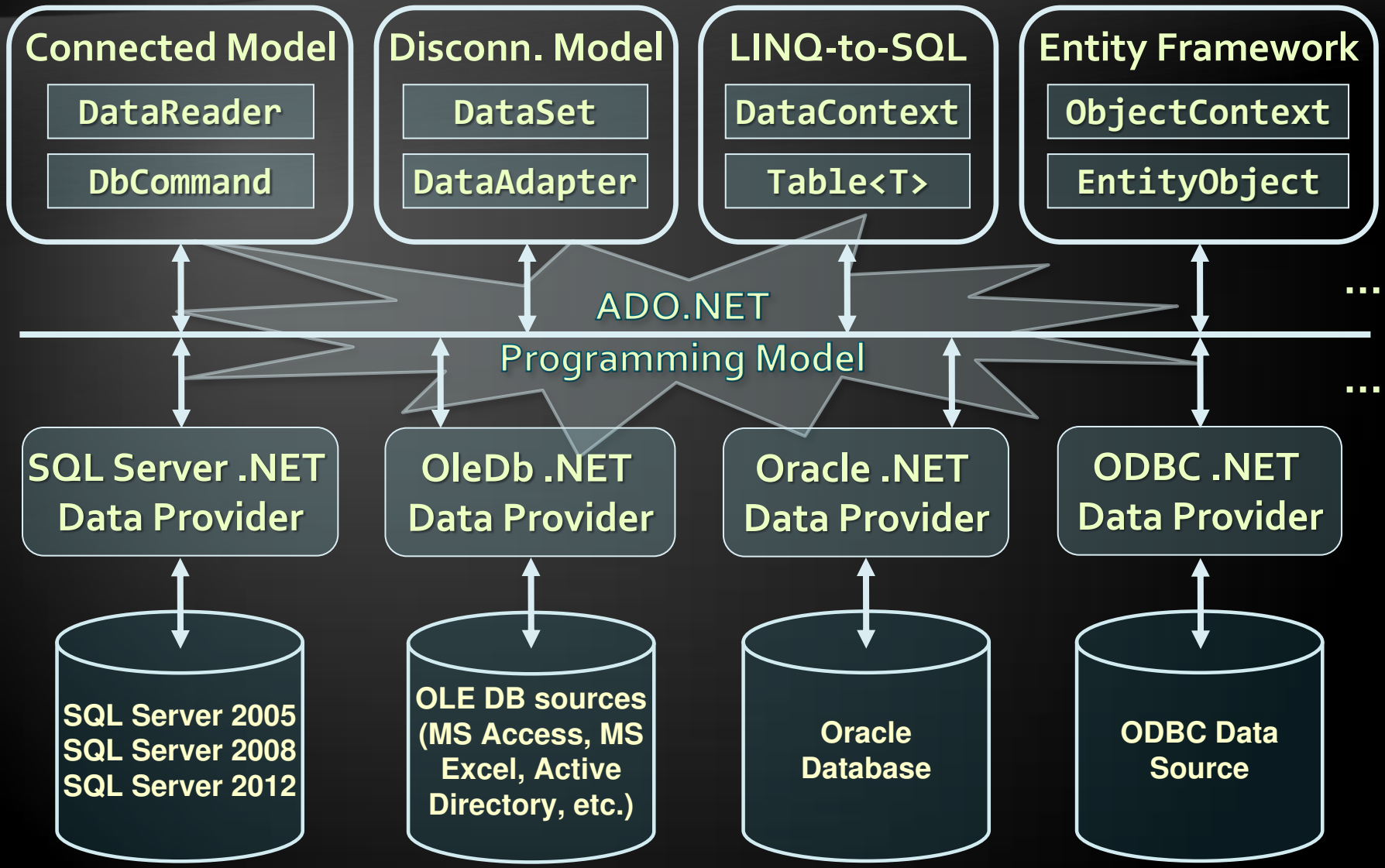
Namespaces In ADO.NET

- `System.Data`
  - ADO.NET core classes
- `System.Data.Common`
  - Common classes for all ADO.NET technologies
- `System.Data.Linq`
  - LINQ-to-SQL framework classes
- `System.Data.Entity`
  - Entity Framework classes
- `System.Xml`
  - XML processing classes

Components of ADO.NET



Data Providers In ADO.NET

- Data Providers are collections of classes that provide access to various databases
  - For different RDBMS systems different Data Providers are available
    - Each provider uses vendor-specific protocols to talk to the database server
  - Several common objects are defined:
    - `Connection` – to connect to the database
    - `Command` – to run an SQL command
    - `DataReader` – to retrieve data

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Data Providers in ADO.NET (2)

- Several standard ADO.NET Data Providers come as part of .NET Framework
  - `SqlClient` – accessing SQL Server
  - `OleDB` – accessing standard OLE DB data sources
  - `Odbc` – accessing standard ODBC data sources
  - `Oracle` – accessing Oracle database
- Third party Data Providers are available for:
  - MySQL, PostgreSQL, Interbase, DB2, SQLite
  - Other RDBMS systems and data sources
    - SQL Azure, Salesforce CRM, Amazon SimpleDB, …

Data Provider Classes

- `System.Data.SqlClient` and `System.Data.SqlTypes`
  - Data Provider classes for accessing SQL Server
- `System.Data.OleDb`
  - Classes for accessing OLE DB data sources
- `System.Data.Odbc`
  - Classes for accessing ODBC data sources
- `System.Data.Oracle`
  - Classes for accessing Oracle databases

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Primary Provider Classes and Interfaces in ADO.NET

Generic Interface	Base Classes	SqlClient Classes
IDbConnection	DbConnection	SqlConnection
IDbCommand	DbCommand	SqlCommand
IDataReader / IDataRecord	DbDataReader	SqlDataReader
IDbTransaction	DbTransaction	SqlTransaction
IDbDataParameter	DbParameter	SqlParameter
IDataParameterCollection	DbParameterCollection	SqlParameterCollection
IDbDataAdapter	DbDataAdapter	SqlDataAdapter
	DbCommandBuilder	SqlCommandBuilder
	DBDataPermission	SqlPermission

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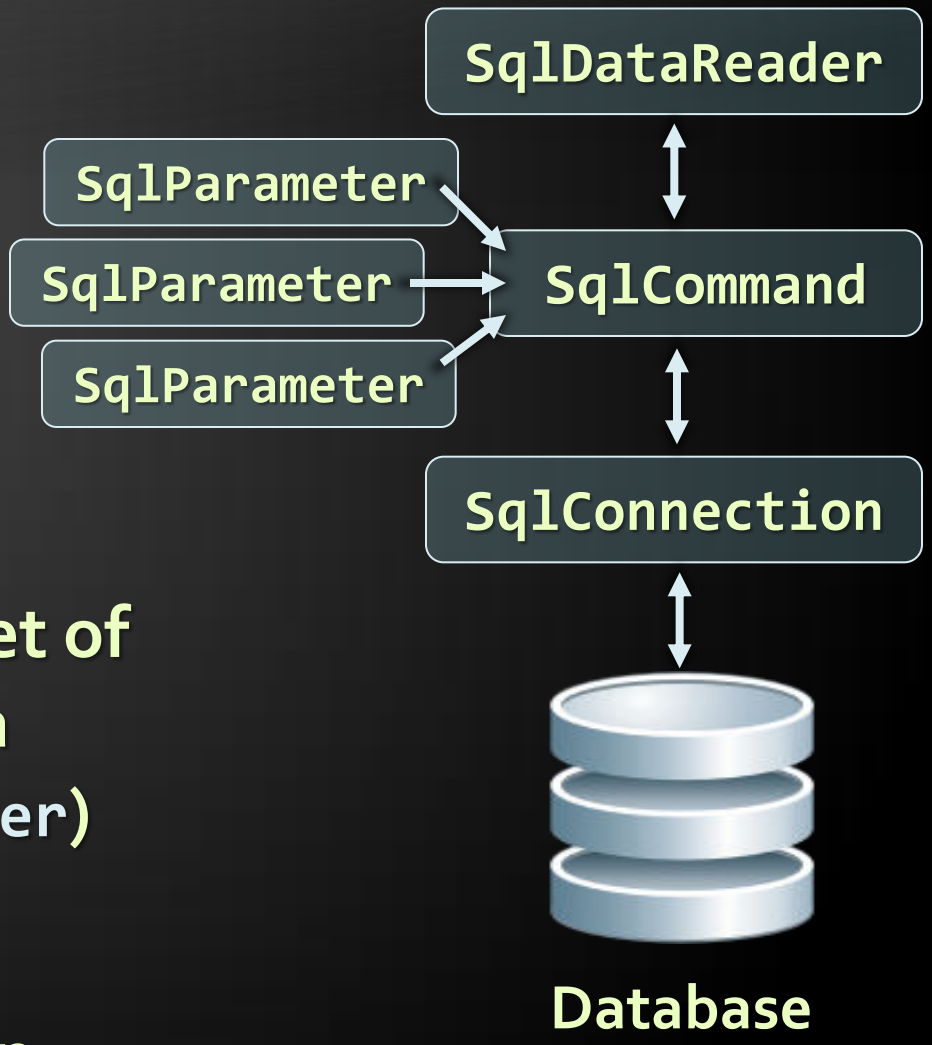
ADO.NET: Connected Model

- Retrieving data in connected model
  1. Open a connection (`SqlConnection`)
  2. Execute command (`SqlCommand`)
  3. Process the result set of the query by using a reader (`SqlDataReader`)
  4. Close the reader
  5. Close the connection



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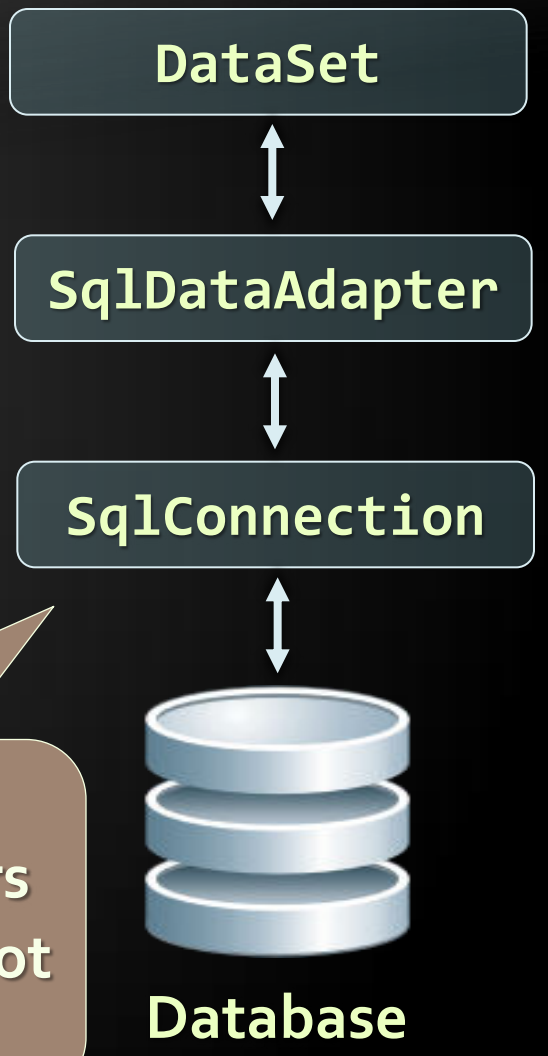
ADO.NET: Disconnected Model

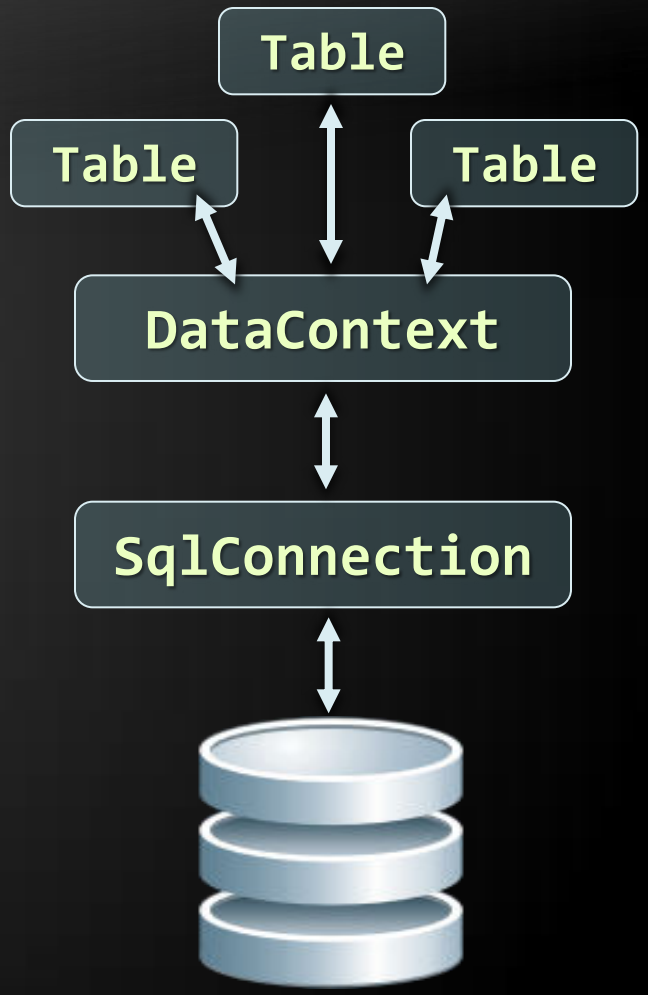
- Disconnected model: the data is cached in a DataSet
  1. Open a connection (SqlConnection)
  2. Fill a DataSet (using SqlDataAdapter)
  3. Close the connection
  4. Modify the DataSet
  5. Open a con
  6. Update cha
  7. Close the co



Warning: DataSets / DataAdapters are legacy technology (not in use since .NET 3.5)

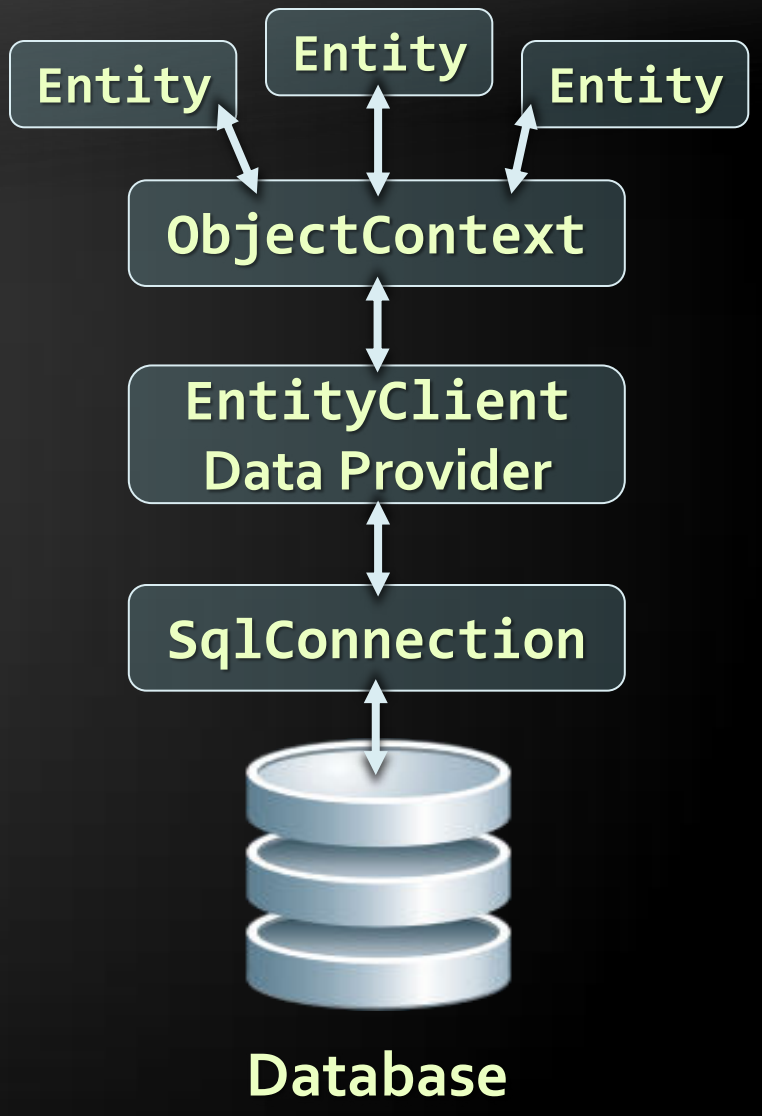
ADO.NET: LINQ-to-SQL

- LINQ-to-SQL is ORM framework for SQL Server
  1. Create object models mapping the database
  2. Open a data context
  3. Retrieve data with LINQ / modify the tables in the data context
  4. Persist the data context changes into the DB
  5. Connection is auto-closed



ADO.NET: Entity Framework

- Entity Framework is generic ORM framework
  1. Create entity data model mapping the database
  2. Open an object context
  3. Retrieve data with LINQ / modify the tables in the object context
  4. Persist the object context changes into the DB
  5. Connection is auto-closed



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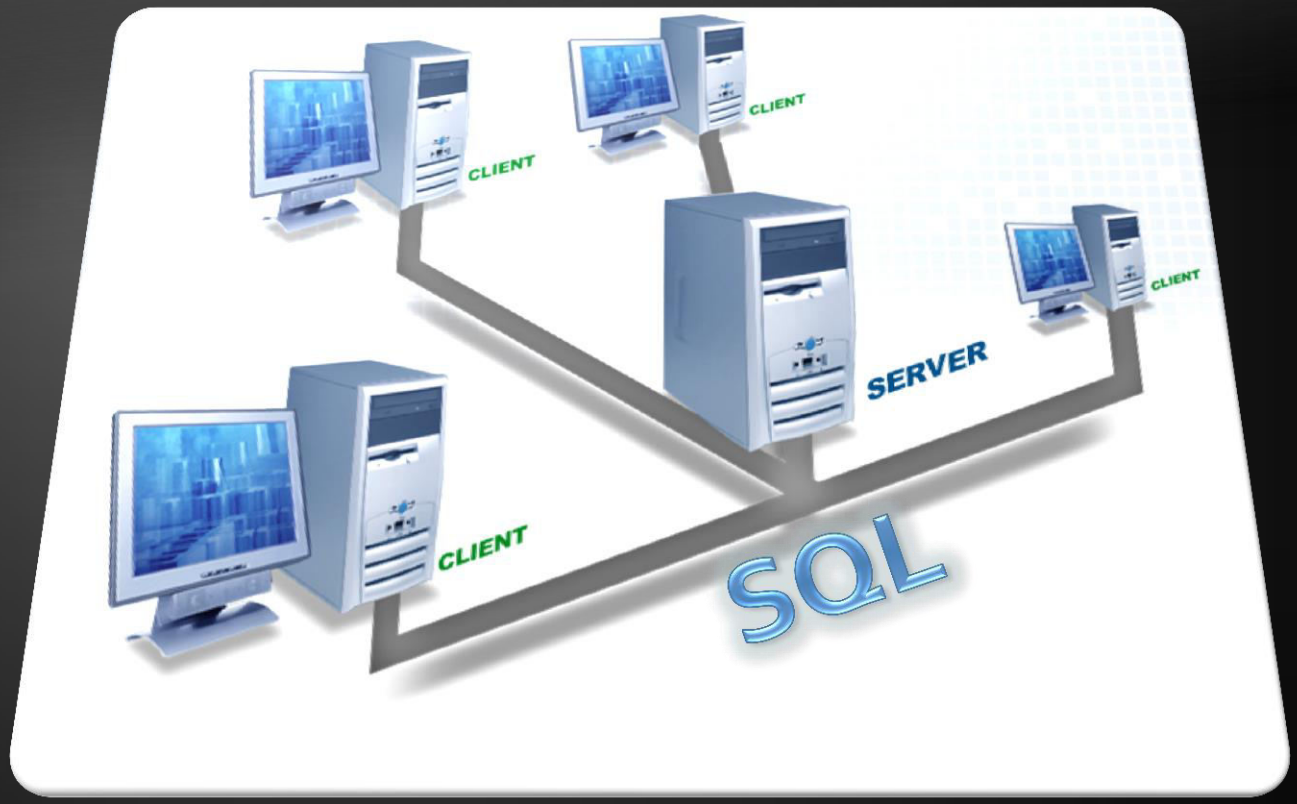

SQL Client Data Provider

SqlClient Data Provider

- `SqlConnection`
  - Establish database connection to SQL Server
- `SqlCommand`
  - Executes SQL commands on the SQL Server through an established connection
  - Could accept parameters (`SQLParameter`)
- `SqlDataReader`
  - Retrieves data (record set) from SQL Server as a result of SQL query execution

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The SqlConnection Class

- SqlConnection establish connection to SQL Server database
  - Requires a valid connection string
- Connection string example:

```
Data Source=(local)\SQLEXPRESS;Initial
Catalog=Northwind;Integrated Security=SSPI;
```

- Connecting to SQL Server:

```
SqlConnection con = new SqlConnection(
  "Server=.\SQLEXPRESS;Database=Northwind;
   Integrated Security=true");
con.Open();
```

DB Connection String

- Database connection string
  - Defines the parameters needed to establish the connection to the database
- Settings for SQL Server connections:
  - `Provider` – name of the DB driver
  - `Data Source` / `Server` – server name / IP address + database instance name
  - `Database` / `Initial Catalog` – database name
  - `User ID` / `Password` – credentials

DB Connection String (2)

- Settings for SQL Server connections:
  - `AttachDbFilename=some_db.mdf`
    - Attaches a local database file
    - Supported by SQL Express only
  - `Server=server_name\database_instance`
    - `"."` or `"(local)"` or `"SOME_SERVER"`
    - Database instance is `"MSSQL"`, `"SQLEXPRESS"` or other SQL Server instance name
  - `Integrated Security` – true / false

Connection Pooling

- By default SqlClient Data Provider uses connection pooling for improved performance
- Connection pooling works as follows:
  - When establishing a connection an existing one is taken from the so called "connection pool"
    - If there is no free connection in the pool, a new connection is established
  - When closing a connection it is returned to the pool, instead of being closed

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Working with SqlConnection

- Explicitly opening and closing a connection
  - Open() and Close() methods
  - Works through the connection pool
- DB connections are IDisposable objects
  - Always use the using construct in C#!
- Implicitly opening and closing the connection
  - Done automatically by DataAdapters, DataContexts and ObjectContexts
  - EF opens / closes the DB connection implicitly

SqlConnection – Example

- Creating and opening connection to SQL Server (database TelerikAcademy)

```
SqlConnection dbCon = new SqlConnection(
  "Server=.\\SQLEXPRESS; " +
  "Database=TelerikAcademy; " +
  "Integrated Security=true");
dbCon.Open();
using (dbCon)
{
  // Use the connection to execute SQL commands here …
}
```

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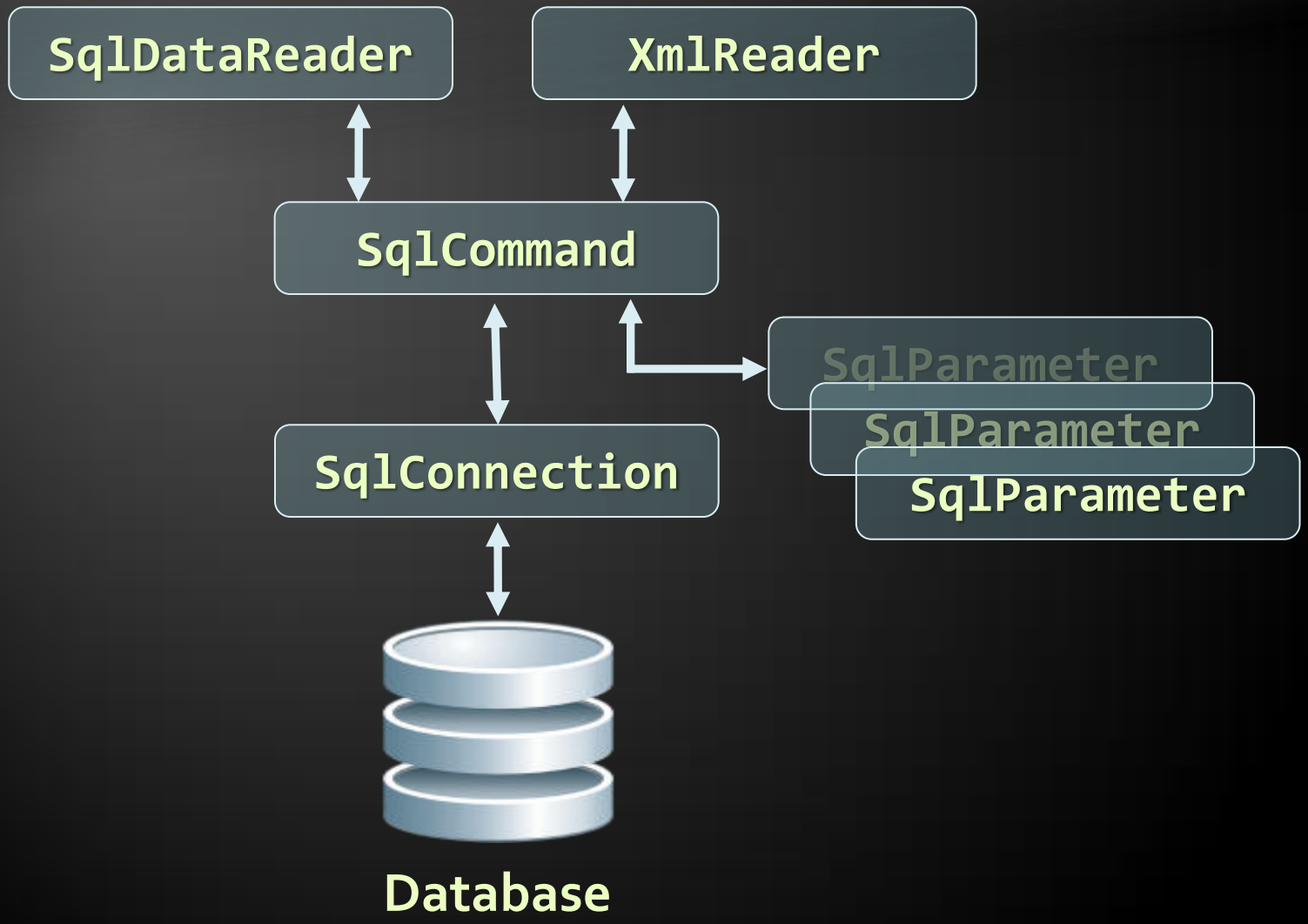
ADO.NET Classes for the Connected Model



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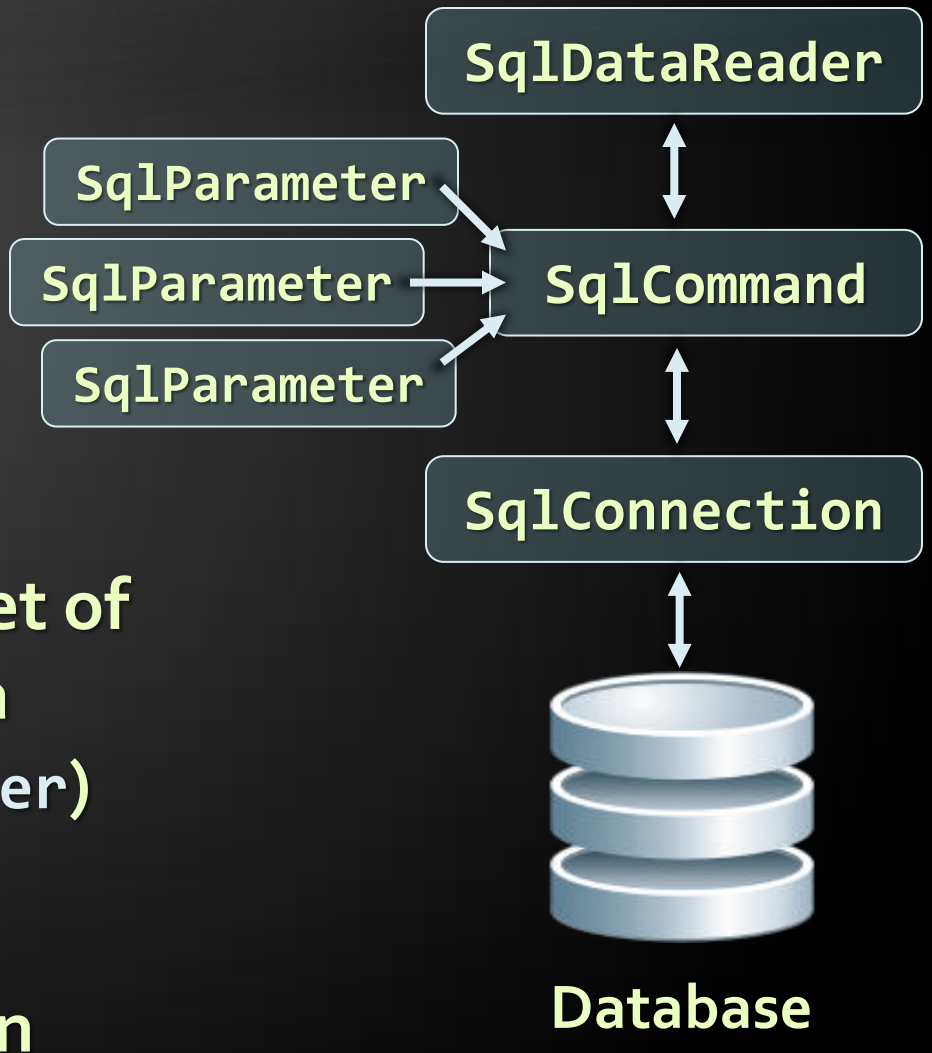
SqlClient and ADO.NET Connected Model

- Retrieving data in connected model
  1. Open a connection (`SqlConnection`)
  2. Execute command (`SqlCommand`)
  3. Process the result set of the query by using a reader (`SqlDataReader`)
  4. Close the reader
  5. Close the connection



The SqlCommand Class

- Executes an SQL statement or a stored procedure
- More important properties
  - `Connection` – gets / sets the `SqlConnection` of the command
  - `CommandType` – the type of the command
    - `CommandType.StoredProcedure`
    - `CommandType.TableDirect`
    - `CommandType.Text`
  - `CommandText` – the body of the SQL query or the name of the stored procedure
  - `Parameters`

The SqlCommand Class (2)

- More important methods
  - `ExecuteScalar()`
    - Returns a single value (the value in the first column of the first row of the result set)
    - The returned value is `System.Object` but can be casted to the actual returned data type
  - `ExecuteReader()`
    - Returns a `SqlDataReader`
      - It is a cursor over the returned records (result set)
    - `CommandBehavior` – assigns some options

The SqlCommand Class (3)

- More important methods
  - `ExecuteNonQuery()`
    - Used for non-query SQL commands, e.g. `INSERT`
    - Returns the number of affected rows (`int`)
  - `ExecuteXmlReader()`
    - Returns the record set as XML
    - Returns an `XmlReader`
    - Supported in SqlClient Data Provider only

The SqlDataReader Class

- `SqlDataReader` retrieves a sequence of records (cursor) returned as result of an SQL command
  - Data is available for reading only (can't be changed)
  - Forward-only row processing (no move back)
- Important properties and methods:
  - `Read()` – moves the cursor forward and returns `false` if there is no next record
  - `Item` (indexer) – retrieves the value in the current record by given column name or index
  - `Close()` – closes the cursor and releases resources

SqlCommand – Example

```
SqlConnection dbCon = new SqlConnection(
  "Server=.\\SQLEXPRESS; " +
  "Database=TelerikAcademy; " +
  "Integrated Security=true");
dbCon.Open();
using(dbCon)
{
  SqlCommand command = new SqlCommand(
    "SELECT COUNT(*) FROM Employees", dbCon);
  int employeesCount = (int) command.ExecuteScalar();
  Console.WriteLine(
    "Employees count: {0} ", employeesCount);
}
```

SqlDataReader – Example

```
SqlConnection dbCon = new SqlConnection(…);
dbCon.Open();
using(dbCon)
{
  SqlCommand command = new SqlCommand(
    "SELECT * FROM Employees", dbCon);
  SqlDataReader reader = command.ExecuteReader();
  using (reader)
  {
    while (reader.Read())
    {
      string firstName = (string)reader["FirstName"];
      string lastName = (string)reader["LastName"];
      decimal salary = (decimal)reader["Salary"];
      Console.WriteLine("{0} {1} - {2}",
        firstName, lastName, salary);
    }
  }
}
```

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Using SqlCommand and SqlDataReader

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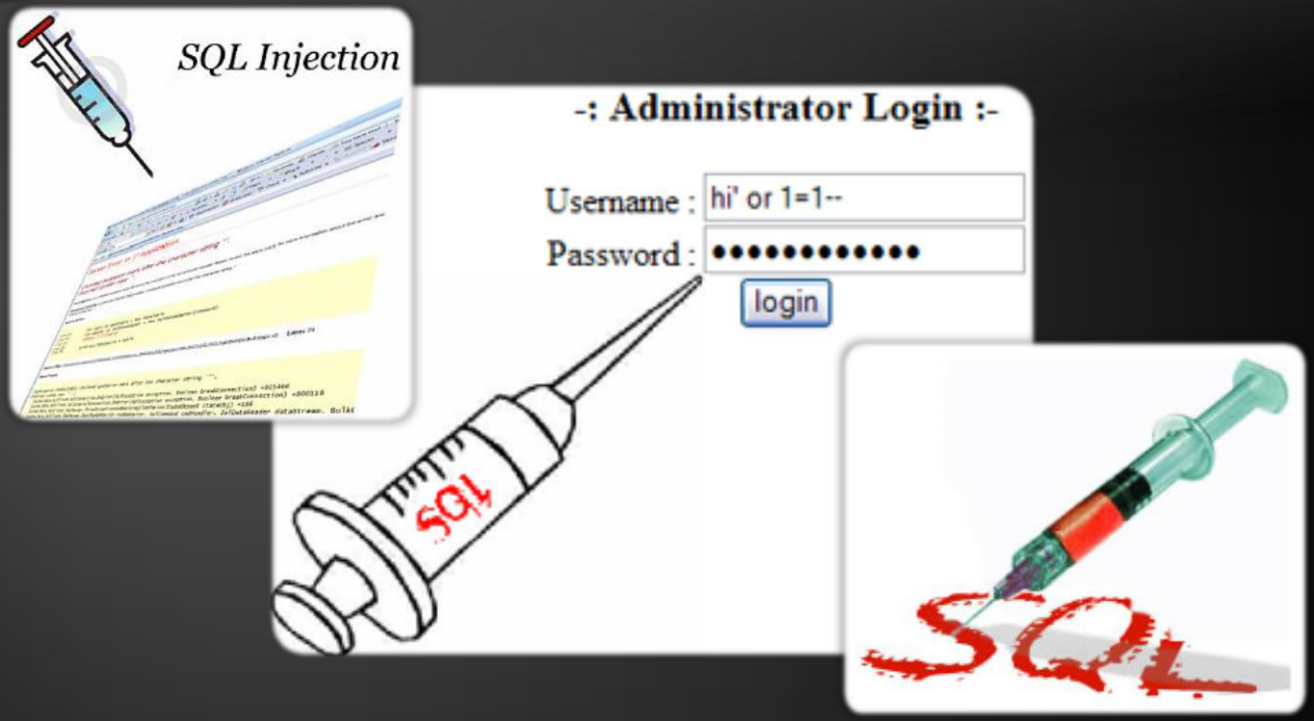

SQL Injection

What is SQL Injection and How to Prevent It?

What is SQL Injection?

```
bool IsPasswordValid(string username, string password)
{
  string sql =
    "SELECT COUNT(*) FROM Users " +
    "WHERE UserName = '" + username + "' and " +
    "PasswordHash = '" + CalcSHA1(password) + "'";
  SqlCommand cmd = new SqlCommand(sql, dbConnection);
  int matchedUsersCount = (int) cmd.ExecuteScalar();
  return matchedUsersCount > 0;
}

bool normalLogin =
  IsPasswordValid("peter", "qwerty123"); // true
bool sqlInjectedLogin =
  IsPasswordValid(" ' or 1=1 --", "qwerty123"); // true
bool evilHackerCreatesNewUser = IsPasswordValid(
  "' INSERT INTO Users VALUES('hacker','') --", "qwerty123");
```

How Does SQL Injection Work?

- The following SQL commands are executed:
  - Usual password check (no SQL injection):

```
SELECT COUNT(*) FROM Users WHERE UserName = 'peter'
and PasswordHash = 'XOwXWxZePV5iyeE86Ejvb+rIG/8='
```

  - SQL-injected password check:

```
SELECT COUNT(*) FROM Users WHERE UserName = ' ' or 1=1
-- ' and PasswordHash = 'XOwXWxZePV5iyeE86Ejvb+rIG/8='
```

  - SQL-injected INSERT command:

```
SELECT COUNT(*) FROM Users WHERE UserName = ''
INSERT INTO Users VALUES('hacker','')
--' and PasswordHash = 'XOwXWxZePV5iyeE86Ejvb+rIG/8='
```

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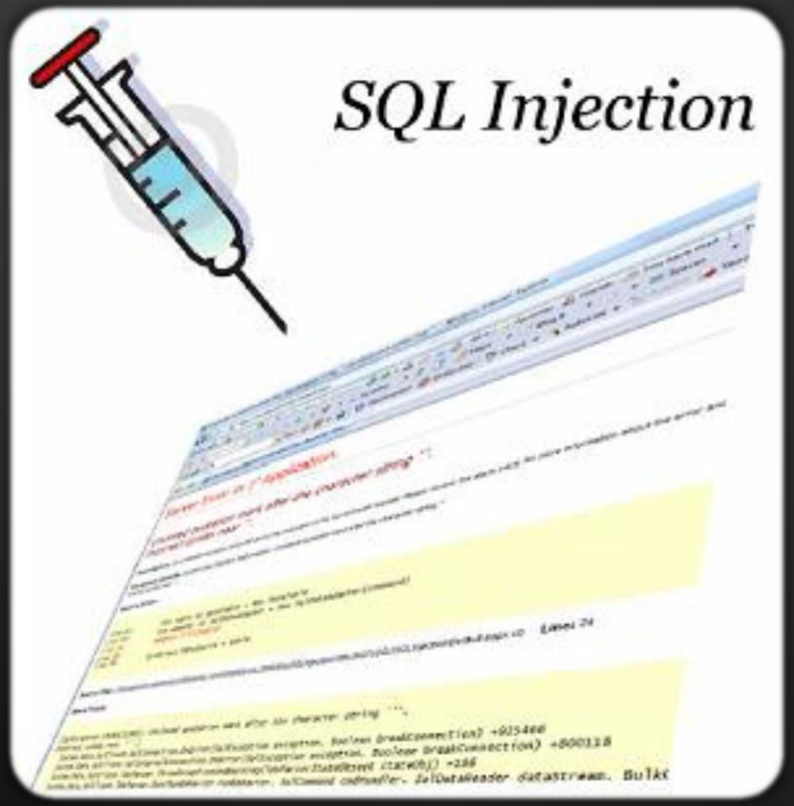

SQL Injection

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Preventing SQL Injection

- Ways to prevent the SQL injection:
  - SQL-escape all data coming from the user:

```
string escapedUsername = username.Replace("'", "''");
string sql =
    "SELECT COUNT(*) FROM Users " +
    "WHERE UserName = '" + escapedUsername + "' and " +
    "PasswordHash = '" + CalcSHA1(password) + "'";
```

    - Not recommended: use as last resort only!
  - Preferred approach:
    - Use parameterized queries
    - Separate the SQL command from its arguments

The SqlParameter Class

- What are SqlParameters?
  - SQL queries and stored procedures can have input and output parameters
  - Accessed through the Parameters property of the SqlCommand class
- Properties of SqlParameter:
  - ParameterName – name of the parameter
  - DbType – SQL type (NVarChar, Timestamp, …)
  - Size – size of the type (if applicable)
  - Direction – input / output

Parameterized Commands – Example

```
private void InsertProject(string name, string description,
  DateTime startDate, DateTime? endDate)
{
  SqlCommand cmd = new SqlCommand("INSERT INTO Projects " +
    "(Name, Description, StartDate, EndDate) VALUES " +
    "(@name, @desc, @start, @end)", dbCon);
  cmd.Parameters.AddWithValue("@name", name);
  cmd.Parameters.AddWithValue("@desc", description);
  cmd.Parameters.AddWithValue("@start", startDate);
  SqlParameter sqlParameterEndDate =
    new SqlParameter("@end", endDate);
  if (endDate == null)
    sqlParameterEndDate.Value = DBNull.Value;
  cmd.Parameters.Add(sqlParameterEndDate);
  cmd.ExecuteNonQuery();
}
```

Primary Key Retrieval

- Retrieval of an automatically generated primary key is specific to each database server
- In MS SQL Server `IDENTITY` column is used
  - Obtained by executing the following query:

```
SELECT @@Identity
```

- Example of obtaining the automatically generated primary key in ADO.NET:

```
SqlCommand selectIdentityCommand =
    new SqlCommand("SELECT @@Identity", dbCon);
int insertedRecordId = (int)
  (decimal) selectIdentityCommand.ExecuteScalar();
```

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Parameterized Queries

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Connecting to Non-Microsoft Databases

Connecting to Non-Microsoft Databases

- ADO.NET supports accessing various databases via their Data Providers:
  - OLE DB – supported internally in ADO.NET
    - Access any OLE DB-compliant data source
    - E.g. MS Access, MS Excel, MS Project, MS Exchange, Windows Active Directory, text files
  - Oracle – supported internally in ADO.NET
  - MySQL – third party extension
  - PostgreSQL – third party extension

ADO.NET Data Interfaces

- ADO.NET Data Providers implement the following interfaces:
  - `IDbConnection`
  - `IDbCommand`, `IDataParameter`
  - `IDataReader`
  - `IDbDataAdapter`

ADO.NET Base Classes

- ADO.NET provides the following base classes:
  - DbConnection
  - DbCommand / DbParameter
  - DbDataReader
  - DbTransaction
  - DbParameterCollection
  - DbDataAdapter
  - DbCommandBuilder
  - DbConnectionStringBuilder
  - DBDataPermission

OLE DB Data Provider

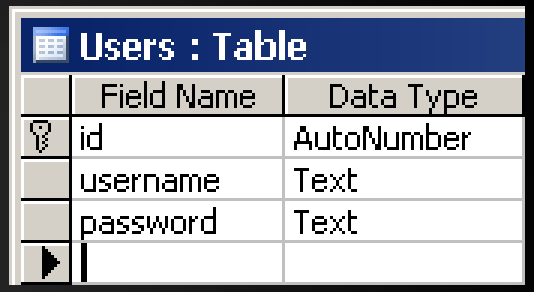
- `OleDbConnection` – establishes a connection to an OLE DB source of data

```
OleDbConnection dbConn = new OleDbConnection(
  @"Provider=Microsoft.Jet.OLEDB.4.0;Data
  Source=C:\MyDB.mdb;Persist Security Info=False");
```

- `OleDbCommand` – executes an SQL commands through an OLE DB connection to a DB
- `OleDbParameter` – parameter for a command
- `OleDbDataReader` – to retrieve data from a command, executed through OLE DB

Connecting To OLE DB – Example

- Suppose we have MS Access database `C:\Library.mdb`
- We have the table `Users`:



- We use the "Microsoft Jet 4.0 Provider" to connect in ADO.NET through OLE DB
- We create a connection string component:

```
Provider=Microsoft.Jet.OLEDB.4.0;Data Source=
C:\Library.mdb;Persist Security Info=False
```

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Connecting to MS Access Database

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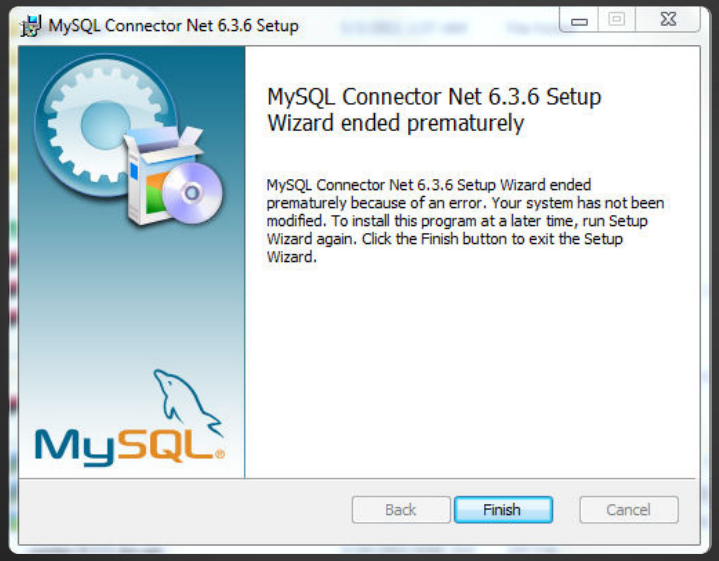

Connecting to MySQL

Accessing MySQL from ADO.NET

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Connecting to MySQL from C#

- Download and install MySQL Connector/Net
  - http://dev.mysql.com/downloads/connector/net/
- Add reference to `MySQL.Data.dll`
  - Available also from NuGet (see http://nuget.org/packages/Mysql.Data/)
- Connecting to MySQL:

```
MySqlConnection dbConnection =
  new MySqlConnection("Server=localhost; Port=3306;
Database=world; Uid=root; Pwd=root; pooling=true");
```

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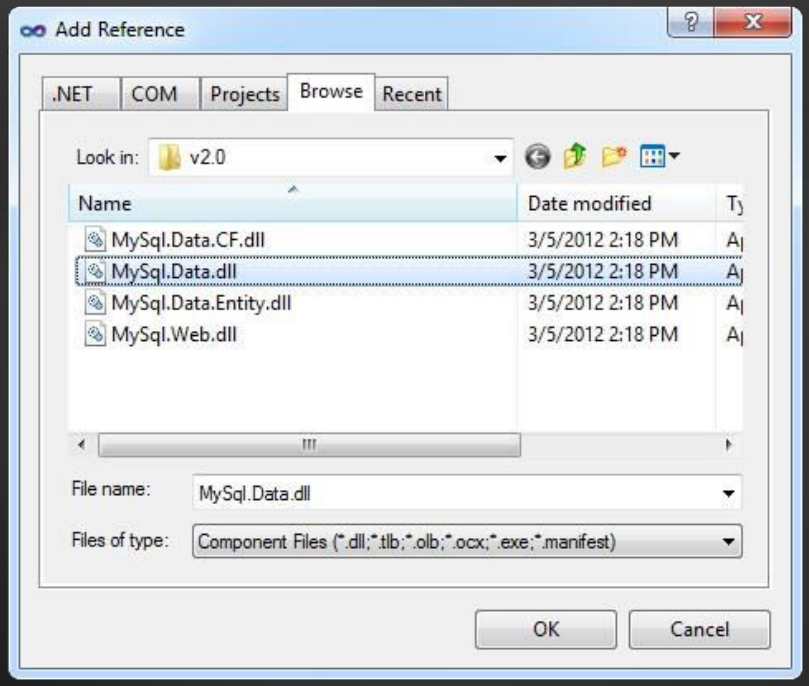

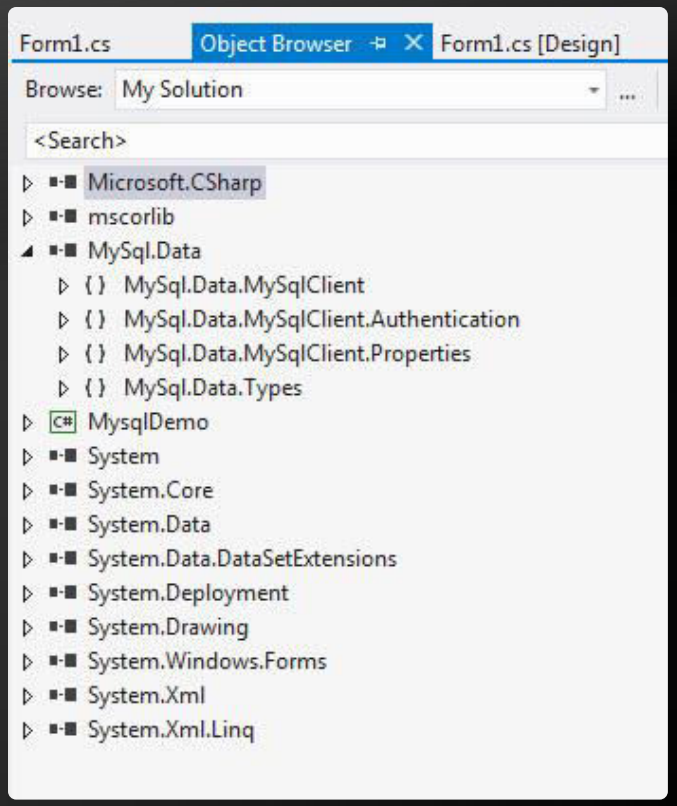

Connecting to MySQL

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Working with Dates and Images

Best Practices

Working with Dates: Best Practices

- Use the date-specific types in the database and never `varchar` / `nvarchar`
- Some databases support more than one type for storing dates
  - Two types in MS SQL Server: `datetime` (8 bytes) and `smalldatetime` (4 bytes)
- When working with dates use string only when displaying the date to the user

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Working with Dates: Best Practices (2)

- Use the `System.DateTime` structure to work with dates in .NET
- Use parameterized queries to pass the dates to the database
- If you need to convert use `IFormatProvider` to define the rules for the conversion
- When needed use the neutral culture settings: `CultureInfo.InvariantCulture`

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Working with Dates – Example

```
CREATE TABLE Messages
(
  MsgId int identity not null primary key,
  MsgText nvarchar(1000),
  MsgDate datetime -- Don't use varchar for dates!
)

public void AddMsg(string text, DateTime date)
{
  SqlCommand cmdInsertMsg = new SqlCommand(
    "INSERT INTO Messages(MsgText, MsgDate) " +
    "VALUES (@MsgText, @MsgDate)", dbCon);
  cmdInsertMsg.Parameters.AddWithValue(
    "@MsgText", text);
  cmdInsertMsg.Parameters.AddWithValue(
    "@MsgDate", date);
  cmdInsertMsg.ExecuteNonQuery();
}
```

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Working With Dates

Live Demo

Storing Images in the DB

- Store images in the file system or in the DB?
  - Have a good reason to use the DB!
- DB field types for large binary objects:
  - Type "`image`" in MS SQL Server
  - Type "`blob`" in Oracle
  - Type "`OLE Object`" in MS Access
- Map the `image` columns to `byte[]`
  - When the files are large, use stream-based access to the binary database fields

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Images in the Database

Live Demo

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Data Access with ADO.NET

Exercises

1. Write a program that retrieves from the `Northwind` sample database in MS SQL Server the number of rows in the `Categories` table.
2. Write a program that retrieves the name and description of all categories in the `Northwind` DB.
3. Write a program that retrieves from the `Northwind` database all product categories and the names of the products in each category. Can you do this with a single SQL query (with table join)?
4. Write a method that adds a new product in the products table in the `Northwind` database. Use a parameterized SQL command.

Exercises (2)

5. Write a program that retrieves the images for all categories in the `Northwind` database and stores them as JPG files in the file system.
6. Create an Excel file with 2 columns: name and score:

	A	B	C	D
1	**Name**	**Score**		
2	Svetlin Nakov	25		
3	Doncho Minkov	22		
4	Nikolay Kostov	24		
5	George Georgiev	20		

   Write a program that reads your MS Excel file through the OLE DB data provider and displays the name and score row by row.
7. Implement appending new rows to the Excel file.

Exercises (3)

8. Write a program that reads a string from the console and finds all products that contain this string. Ensure you handle correctly characters like ' , %, " , \ and _.
9. Download and install MySQL database, MySQL Connector/Net (.NET Data Provider for MySQL) + MySQL Workbench GUI administration tool . Create a MySQL database to store Books (title, author, publish date and ISBN). Write methods for listing all books, finding a book by name and adding a book.
10. Re-implement the previous task with SQLite embedded DB (see http://sqlite.phxsoftware.com).

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