

Database access in C# using LINQ

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ADO.NET

- **ADO.NET provides a direct interface to a database.**
- **The interface is database-specific.**
- **ADO.NET uses a conventional, shallow embedding of SQL commands into C# as host language, i.e. SQL commands are composed as strings.**
- **A more advanced, deep embedding of SQL commands is provided by LINQ, i.e. SQL commands a language constructs.**

Structure of database access

To access a database with ADO.NET the following steps are necessary:

- Connect to a database
- Compose an SQL query
- Issue the query
- Retrieve and process the results
- Disconnect from the database.

ADO.NET Example

To connect to a database, a connection string has to specify location, account, password etc. (fill in user id and pwd):

```
1 using MySql.Data.MySqlClient;
2 string cstr = "Server=anubis;Database=test;User_ID=;
   Password=";
3 MySqlConnection dbcon;
4
5 try {
6     dbcon = new MySqlConnection(cstr);
7     dbcon.Open();
8 } catch (MySql.Data.MySqlClient.MySqlException ex) {
   ... }
```

ADO.NET Example (cont'd)

- Next, compose an SQL query as a string
- This can be any SQL operation
- Depending on the underlying database, SQL extensions might be available.

```
1 MySqlCommand dbcmd = dbcon.CreateCommand();  
2  
3 string sql = "SELECT A_ID, A_FNAME, A_LNAME" +  
4             "FROM authors";  
5 dbcmd.CommandText = sql;
```

ADO.NET Example (cont'd)

Next, issue the query, and process the result, typically in a while loop.

```
1 MySqlDataReader reader = dbcmd.ExecuteReader();  
2  
3 while(reader.Read()) {  
4     string FirstName = (string) reader["A_FNAME"];  
5     string LastName = (string) reader["A_LNAME"];  
6     Console.WriteLine("Name:␣" + FirstName + "␣" +  
7         LastName);  
8 }
```

ADO.NET Example (cont'd)

Finally, clean-up and disconnect.

```
1 reader.Close();  
2 reader = null;  
3 dbcmd.Dispose();  
4 dbcmd = null;  
5 dbcon.Close();  
6 dbcon = null;
```

LINQ

- Language Integrated Query (LINQ) is a more advanced way to interact with databases.
- It's a new feature with C# 3.0 onwards.
- It provides SQL-like commands as language extensions, rather than composing SQL queries as strings (*deep embedding*)
- It can also be used to access other forms of data, such as XML data or compound C# data structures.

LINQ Example

- The same example as before, written in LINQ is much simpler.
- First, classes, representing the tables of the database are defined.

```
1 [Table(Name = "authors")]
2 public class Authors
3 {
4     [Column]
5     public int A_ID    { get ; set ; }
6     [Column]
7     public string A_FNAME { get ; set ; }
8     [Column]
9     public string A_LNAME { get ; set ; }
10 }
```

LINQ Example (cont'd)

Next, a connection is established, using a connection string similar to ADO.NET:

```
1 DataContext db =  
2     new DataContext("Data□Source□=□.\□\MySQL;" +  
3                     "Initial□Catalog=test;Integrated□  
4                     Security=True");  
5 DataContext db = new DataContext(connStr);
```

LINQ Example (cont'd)

The main advantage of LINQ is the simplified way of performing queries.

```
1 Table<Authors> AuthorTable = db.GetTable<Authors>();  
2 List<Authors> dbQuery = from author in Authors select  
    author ;  
3  
4 foreach (var author in dbQuery) {  
5     Console.WriteLine("Author:␣"+author.A_FNAME+' ' +  
        author.A_LNAME);  
6 }
```

Note, that SQL-like commands such as **select**, **from** etc are directly available

Querying in-memory Data

- LINQ can also be used to query in-memory data, such as XML data or compound C# data structures.
- This results in more uniform and succinct code.
- Using LINQ in this way requires several advanced language features.
- It is an alternative to using standard mechanisms of traversing data structures such as iterators.

Example

Assume we have a list of books:

```
1 List<Book> booklist = new List<Book> {  
2     new Book { Title = "Learning_C#"   
3         , Author = "Jesse_Liberty"  
4         , Publisher = "O'Reilly"  
5         , Year = 2008  
6     },  
7     new Book { Title = "Programming_C#"   
8         , Author = "Jesse_Liberty"  
9         , Publisher = "O'Reilly"  
10        , Year = 2008  
11    },  
12    new Book { Title = "Programming_PHP"   
13        , Author = "Rasmus_Lerdorf, Kevin_  
14            Tatroe"  
15        , Publisher = "O'Reilly"  
16        , Year = 2006  
17    },
```

Example (conventional)

The conventional way to iterate over the list looks like this:

```
1 foreach (Book b in booklist) {  
2     if (b.Author == "Jesse_Liberty") {  
3         Console.WriteLine(b.Title + "_by_" + b.Author);  
4     }  
5 }
```

Example (LINQ)

In contrast, the LINQ-style iteration looks like an SQL query and is shorter:

```
1 IEnumerable<Book> resultsAuthor =  
2     from b in booklist  
3     where b.Author == "JesseLiberty"  
4     select b;  
5  
6 Console.WriteLine("LINQ query: find by author...");  
7 // process the result  
8 foreach (Book r in resultsAuthor) {  
9     Console.WriteLine(r.Title + " by " + r.Author);  
10 }
```

Example (LINQ)

In contrast, the LINQ-style iteration looks like an SQL query and is shorter:

```
1 IEnumerable<Book> resultsAuthor =
2     from b in booklist
3     where b.Author == "JesseLiberty"
4     select b; Embedded SQL-like code (LINQ code)
5
6 Console.WriteLine("LINQ query: find by author...");
7 // process the result
8 foreach (Book r in resultsAuthor) {
9     Console.WriteLine(r.Title + " by " + r.Author);
10 }
```

Example (LINQ)

In contrast, the LINQ-style iteration looks like an SQL query and is shorter:

```
1 IEnumerable<Book> resultsAuthor =  
2     from b in booklist  
3     where b.Author == "JesseLiberty"  
4     select b; Embedded SQL-like code (LINQ code)  
5  
6 Console.WriteLine("LINQ query: find by author...");  
7 // process the result  
8 foreach (Book r in resultsAuthor) {  
9     Console.WriteLine(r.Title + " by " + r.Author);  
10 } Iterate over the results
```

Example (with anonymous types)

To avoid returning entire book results from the query we can use *anonymous types* and just return title and author:

```
1 // NB: this needs to infer the type (anonymous!)
2 var resultsAuthor1 =
3     from b in booklist
4     where b.Author == "Jesse_Liberty"
5     // NB: anonymous type here!
6     select new { b.Title, b.Author } ;
7
8 // process the result
9 foreach (var r in resultsAuthor1) {
10     Console.WriteLine(r.Title + "_by_" + r.Author);
11 }
```

Example (with anonymous types)

To avoid returning entire book results from the query we can use *anonymous types* and just return title and author:

```
1 // NB: this needs to infer the type (anonymous!)
2 var resultsAuthor1 = Anonymous type (var)
3     from b in booklist
4     where b.Author == "Jesse_Liberty"
5     // NB: anonymous type here!
6     select new { b.Title, b.Author } ;
7
8 // process the result
9 foreach (var r in resultsAuthor1) {
10     Console.WriteLine(r.Title + "_by_" + r.Author);
11 }
```

Example (with lambda expressions)

Lambda expressions can be used to shorten the query even further:

```
1 // NB: lambda expression here
2 var resultsAuthor2 =
3     booklist.Where(bookEval => bookEval.Author == "Jesse_
4         Liberty");
5
6 // process the result
7 foreach (var r in resultsAuthor2) {
8     Console.WriteLine(r.Title + "_by_" + r.Author);
9 }
```

Example (with lambda expressions)

Lambda expressions can be used to shorten the query even further:

```
1 // NB: lambda expression here
2 var resultsAuthor2 =
3     booklist.Where(bookEval => bookEval.Author == "Jesse_
4         Liberty");
5 // process the result
6 foreach (var r in resultsAuthor2) {
7     Console.WriteLine(r.Title + " by " + r.Author);
8 }
```

Lambda expression (anonymous function)

Example (more SQL-like commands)

We can sort the result by author:

```
1 var resultsAuthor3 =  
2     from b in booklist  
3     orderby b.Author  
4     // NB: anonymous type here!  
5     select new { b.Title, b.Author} ;  
6  
7 Console.WriteLine("LINQ query: ordered by author...")  
8 ;  
9 // process the result  
10 foreach (var r in resultsAuthor3) {  
11     Console.WriteLine(r.Title + " by " + r.Author);  
12 }
```

Example (joining tables)

We can join tables like this:

```
1 var resultList4 =  
2     from b in booklist  
3     join p in purchaselist on b.Title equals p.Title  
4     where p.Quantity >=2  
5     select new { b.Title, b.Author, p.Quantity } ;  
6  
7 Console.WriteLine("LINQ query: ordered by author...")  
8 ;  
9 // process the result  
10 foreach (var r in resultList4) {  
11     Console.WriteLine(r.Quantity + " items of "  
12         Title  
            + " by " + r.Author);  
13 }
```

Summary

- **C# supports two ways of querying databases:**
 - ▶ ADO.NET with SQL queries as strings
 - ▶ LINQ with SQL commands embedded into the language
- **ADO.NET is older and more robust**
- **LINQ is newer and easier to use**
- **LINQ can also be used to traverse in-memory data structures.**