

# SQL INJECTION ATTACKS

## INFORMATION IN THIS CHAPTER

- What Is an SQL Injection Attack?
- Why Are SQL Injection Attacks So Successful?
- How to Protect Yourself from an SQL Injection Attack
- Cleaning Up the Database After an SQL Injection Attack

## What Is an SQL Injection Attack?

An SQL Injection Attack is probably the easiest attack to prevent, while being one of the least protected against forms of attack. The core of the attack is that an SQL command is appended to the back end of a form field in the web or application front end (usually through a website), with the intent of breaking the original SQL Script and then running the SQL script that was injected into the form field. This SQL injection most often happens when you have dynamically generated SQL within your front-end application. These attacks are most common with legacy Active Server Pages (ASP) and Hypertext Preprocessor (PHP) applications, but they are still a problem with [ASP.NET](#) web-based applications. The core reason behind an SQL Injection attack comes down to poor coding practices both within the front-end application and within the database stored procedures. Many developers have learned better development practices since [ASP.NET](#) was released, but SQL Injection is still a big problem between the number of legacy applications out there and newer applications built by developers who didn't take SQL Injection seriously while building the application.

As an example, assume that the front-end web application creates a dynamic SQL Script that ends up executing an SQL Script similar to that shown in Example 6.1.

```
SELECT * FROM Orders WHERE OrderId=25
```

**Example 6.1:** A simple dynamic SQL statement as expected from the application.

This SQL Script is created when the customer goes to the sales order history portion of the company's website. The value passed in as the OrderId is taken from the query string in the URL, so the query shown above is created when the customer goes to the URL <http://www.yourcompany.com/orders/orderhistory.aspx?Id=25>. Within the .NET code, a simple string concatenation is done to put together the SQL Query. So any value that is put at the end of the query string is passed to the database at the end of the select statement. If the attacker were to change the query string to something like “/orderhistory.aspx?id=25; delete from Orders,” then the query sent to the SQL Server will be a little more dangerous to run as shown in Example 6.2.

```
SELECT * FROM Orders WHERE ORderId=25; delete from Orders;
```

**Example 6.2:** A dynamic SQL String that has had a delete statement concatenated to the end of it.

The way the query in Example 6.2 works is that the SQL database is told via the semicolon “;” that the statement has ended and that there is another statement that should be run. The SQL Server then processes the next statement as instructed.

While the initial query is run as normal now, and without any error being generated but when you look at the Orders table, you won't see any records in the Orders table because the second query in that batch will have executed against the database as well. Even if the attacker omits the value that the query is expecting, they can pass in “; delete from Orders;” and while the first query attempting to return the data from the Orders table will fail, the batch will continue moving on to the next statement, which will delete all the records in the Orders table.

Many people will inspect the text of the parameters looking for various key words in order to prevent these SQL Injection attacks. However, this only provides the most rudimentary protection as there are many, many ways to force these attacks to work. Some of these techniques include passing in binary data, having the SQL Server convert the binary data back to a text string, and then executing the string. This can be proven by running the T/SQL statement shown in Example 6.3.

```
DECLARE @v varchar(255)
SELECT @v = cast(0x73705F68656C706462 as varchar(255))
EXEC (@v)
```

**Example 6.3:** Code showing how a binary value can be used to hide a T/SQL statement.

When data is being accepted from a user, either a customer or an employee, one good way to ensure that the value won't be used for an SQL Injection attack is to validate that the data being returned is of the expected data type. If a number is expected, the front-end application should ensure that there is in fact a number within the value. If a text string is expected, then ensure that the text string is of the correct length, and it does not contain any binary data within it. The front-end application should be able to validate all data being passed in from the user, either by informing the user of the problem and allowing the user to correct the issue, or by crashing gracefully in such a way that an error is returned and no commands are sent to the database or the file system. Just because users should be sending up valid data doesn't mean that they are going to. If users could be trusted, most of this book wouldn't be needed.

## Note

### The Database Isn't the Only Weak Spot

If a file name is going to be generated based on the user's input, a few special values should be watched for. These values are Windows file system key words that could be used to give attackers access to something they shouldn't have, or could simply cause havoc on the front-end server.

- AUX
- CLOCK\$
- COM1-COM8
- CON
- CONFIG\$
- LPT1-LPT8
- NUL
- PRN

By allowing an attacker to create a file path using these special names, attackers could send data to a serial port by using COM1 (or whatever com port number they specify) or to a printer port using LPT1 (or whatever printer port they specify). Bogus data could be sent to the system clock by using the CLOCK\$ value, or they could instruct the file to be written to NUL, causing the file to simply disappear.

The same technique shown in Example 6.3 can be used to send update statements into the database, causing values to be places

within the database that will cause undesirable side effects on the websites powered by the databases. This includes returning javascript to the client computers causing popups that show ads for other projects, using HTML iframes to cause malicious software to be downloaded, using HTML tags to redirect the browser session to another website, and so on.

SQL Injection attacks aren't successful against only in-house applications. A number of third-party applications available for purchase are susceptible to these SQL Injection attacks. When purchasing third-party applications, it is often assumed that the product is a secure application that isn't susceptible to the attack. Unfortunately, that isn't the case, and any time a third-party application is brought into a company, it should be reviewed, with a full code review if possible, to ensure that the application is safe to deploy. When a company deploys a third-party application that is susceptible to attack and that application is successfully attacked, it is the company that deployed the application that will have to deal with the backlash for having an insecure application and their customer data compromised, not the company that produced and sold the insecure application.

Many people think that SQL Injection attacks are a problem unique to Microsoft SQL Server, and those people would be wrong. SQL Injection attacks can occur against Oracle, MySQL, DB2, Access, and so on. Any database that allows multiple statements to be run in the same connection is susceptible to an SQL Injection attack. Now some of the other database platforms have the ability to turn off this function, some by default and some via an optional setting. There are a number of tickets open in the Microsoft bug-tracking website <http://connect.microsoft.com> that are requesting that this ability be removed from a future version of the Microsoft SQL Server product. While doing so would make the Microsoft SQL Server product more secure, it would break a large number of applications, many of which are probably the ones that are susceptible to SQL Injection attacks.

Another technique that is easier to use against Microsoft SQL Server 7 and 2000 is to use the `sp_makewebtask` system stored procedure in the master database. If the attacker can figure out the name of the webserver, which can usually be done pretty easily by looking at the `sysprocesses` table, or the path to the website, then the `sp_makewebtask` procedure can be used to export lists of objects to HTML files on the web server to make it easier for the attacker to see what objects are in the database. Then they can simply browse to the website and see every table in the database.

```
exec master.dbo.sp_makewebtask '\\web1\wwwroot\tables.html",  
"select * from information_schema.tables"
```

Code that an attacker could execute to export all table objects to an HTML file.

If `xp_cmdshell` is enabled on the server, then an attacker could use `xp_cmdshell` to do the same basic thing just by using Bulk Copy Protocol (BCP) instead of `sp_makewebtask`. The advantage to `sp_makewebtask` is that `xp_cmdshell` doesn't need to be enabled, while the downside to `sp_makewebtask` is that it doesn't exist on Microsoft SQL Server 2005 and up. The downside to `xp_cmdshell` is that, unless the application uses a login that is a member of the `sysadmin` fixed server role, the `xp_cmdshell` procedure will only have the rights that are granted by the proxy account. An attacker can use the `xp_cmdshell` procedure to send in the correct commands to give the account that is the proxy account more permissions, or even change the account to one that has the correct permissions. At this point BCP can be used to output whatever data is wanted. The attacker could start with database schema information, and then begin exporting your customer information, or they could use this information to change or delete the data from the database.

The catch to either of these techniques is that the NT File System (NTFS) permissions need to allow either the SQL Server account or the account that the `xp_cmdshell` proxy account uses to have network share and NTFS permissions to the web server. On smaller applications where the web server and the database server are running on the same machine, this is much, much easier as the SQL Server is probably running as the local system account that gives it rights to everything.

## Note

### There Are Lots of Protection Layers to Make Something Secure

Hopefully, by now you are starting to see how the various layers of the Microsoft SQL Server need to be secured to make for a truly secure SQL Server. In this case we look specifically at NTFS permissions combined with the `xp_cmdshell` proxy account, combined with the Windows account that the SQL Server is running under, combined with the application account that logs into SQL having the minimum level of rights, and combined with parameterizing the values from the web application all to create a more secure environment.

To fully protect from an SQL injection attack, the application account should only have the minimum rights needed to function; it should have no rights to `xp_cmdshell`, which should be disabled (or removed from the server). The SQL Server service should be running under a domain or local computer account that only has the rights needed to run as a service and access the SQL Server folders. That Windows account should have no rights to the actual files that are the website files, and it shouldn't be an administrator on the server that is running the SQL Server service

## Note—*Cont'd*

or the web server. The resulting effective permissions that an SQL Server has are to access the database files and do nothing else. Any other functions that the SQL Server instance is expected to perform either via an SQL Agent job or a CLR procedure should be controlled through some sort of account impersonation.

At the application level the actual SQL Server error messages should be masked so that they aren't returned to the client. If you have done these things, then even if attackers were able to successfully complete an SQL Injection attack against the SQL Server they wouldn't be able to do much to the server as they wouldn't have any way to get information back from the SQL Server (as the error messages are masked) and they wouldn't be able to get to the shell and get software downloaded and installed from the outside. Once these things fail a few times, attackers will probably just move on to an easier target.

The amount of time that an attacker will spend trying to successfully use an SQL Injection attack against a web-based application will for the most part depend on the amount of value the target has. A smaller company such as a wholesale food distributor probably won't be attacked very often, and the attacker will probably leave after a short period of time. However, a bank or other financial company will provide a much more enticing target for the attacker, and the attack will probably last much longer, with many more techniques being tried, as well as many combinations of techniques until they successfully break into the database application.

## Why Are SQL Injection Attacks So Successful?

SQL Injection attacks are so successful for a few reasons, the most common of which is that many newer developers simply don't know about the problem. With project timelines being so short, these junior developers don't have the time to research the security implications of using dynamic SQL. These applications then get left in production for months or years, with little to no maintenance. These developers can then move through their career without anyone giving them the guidance needed to prevent these problems.

Now developers aren't solely to blame for SQL Injection attack problems. The IT Management should have policies in place in order to ensure that newer developers that come in don't have the ability to write dynamic inline SQL against the database engine. These policies should include rules like the following:

1. All database interaction must be abstracted through stored procedures.
2. No stored procedure should have dynamic SQL unless there is no other option.

3. Applications should have no access to table or view objects unless required by dynamic SQL, which is allowed under rule #2.
4. All database calls should be parameterized instead of being inline dynamic SQL.
5. No user input should be trusted and thought of as safe; all user interactions are suspect.

## Warning

### SQL Injection Happens at All Levels

Unfortunately, not just small companies can have problems with SQL Injection attacks. In 2009, for example, ZD Net reported that some of the international websites selling Kaspersky antivirus, specifically Kaspersky Iran, Taiwan, and South Korea, were all susceptible to SQL Injection attacks. In the same article (<http://bit.ly/AntiVirusSQLInject>) ZD Net also reported that websites of F-Secure, Symantec, BitDefender, and Kaspersky USA all had problems with SQL Injection attacks on their websites.

These are some of the major security companies of the day, and they are showing a total lack of security by letting their websites fall prey to the simple injection attack. Considering just how simple it is to protect a website from an SQL injection attack, the fact that some of the biggest security companies in the industry were able to have SQL Injection problems on their production customer facing websites is just ridiculous.

Because of how intertwined various websites are with each other, real-estate listing providers and the realtors which get their data from the listing providers, a lot of trust must exist between these companies and the people who use one companies site without knowing that they are using another companies data. This places the company that is showing the real-estate listings to their users in a position of trusting the advertising company to have a safe application. However, this trust can backfire as on a few occasions various partner companies have suffered from SQL Injection attacks, in some cases pushing out malicious software to the users of dozens, hundreds, or thousands of different websites that display the data.

With the introduction of Object Relational Mappings (ORM) such as Link to SQL and nHibernate, the SQL Injection problems are greatly lessened as properly done ORM code will automatically parameterize the SQL queries. However, if the ORM calls stored procedures, and those stored procedures have dynamic SQL within them, the application is still susceptible to SQL Injection attacks.

## How to Protect Yourself from an SQL Injection Attack

Once the command gets to the database to be run by the database engine, it is too late to protect yourself from the SQL

Injection attack. The only way to truly protect your database application from an Injection attack is to do so within the application layer. Any other protection simply won't be anywhere nearly as effective. Some people think that doing a character replacement within the T/SQL code will effectively protect you, and it might to some extent. But depending on how the T/SQL is set up and how the dynamic SQL string is built, it probably won't, at least not for long.

## NET Protection Against SQL Injection

The only surefire way to protect yourself is to parameterize every query that you send to the database. This includes your stored procedure calls, as well as your inline dynamic SQL calls. In addition, you never want to pass string values that the front-end application has allowed the user to enter directly into dynamic SQL within your stored procedure calls. If you have cause to use dynamic SQL within your stored procedures (and yes, there are perfectly legitimate reasons for using dynamic SQL), then the dynamic SQL needs to be parameterized just like the code that is calling the stored procedure or inline dynamic SQL Script. This is done by declaring parameters within the T/SQL statement, and adding those parameters to the SQLCommand object that has the SQL Command that you will be running, as shown in Example 6.4 and Example 6.5.

```
Private Sub MySub()  
    Dim Connection As SqlConnection  
    Dim Results As DataSet  
    Dim SQLda As SqlDataAdapter  
    Dim SQLcmd As SqlCommand  
    SQLcmd = New SqlCommand  
    SQLcmd.CommandText = "sp_help_job"  
    SQLcmd.CommandType = CommandType.StoredProcedure  
    SQLcmd.Parameters.Add("job_name", SqlDbType.VarChar, 50)  
    SQLcmd.Parameters.Item("job_name").Value = "test"  
    Connection = New SqlConnection("Data Source=  
        localhost;Initial Catalog=msdb;Integrated  
        Security=SSPI;")  
    Using Connection  
        Connection.Open()  
        SQLcmd.Connection = Connection  
        SQLda = New SqlDataAdapter(SQLcmd)  
        Results = New DataSet()  
        SQLda.Fill(Results)  
    End Using  
    'Do something with the results from the Results variable here.
```

```

        SQLcmd.Dispose()
        SQLda.Dispose()
        Results.Dispose()
        Connection.Close()
        Connection.Dispose()
    End Sub

```

**Example 6.4:** VB.NET code showing how to use parameters to safely call a stored procedure.

```

private void MySub()
{
    SqlConnection Connection = new SqlConnection("Data
        Source=localhost;Initial Catalog=msdb;Integrated
        Security=SSPI;");
    DataSet Results = new DataSet();
    SqlCommand SQLcmd = new SqlCommand();
    SQLcmd.CommandText = "sp_help_job";
    SQLcmd.CommandType = CommandType.StoredProcedure;
    SqlParameter parm1 = new SqlParameter();
    parm1.ParameterName = "job_name";
    parm1.DbType = DbType.String;
    parm1.Precision = 255;
    parm1.Value = "test";
    SQLcmd.Parameters.Add(parm1);
    Connection.Open();
    SQLcmd.Connection = Connection;
    SqlDataAdapter SQLda = new SqlDataAdapter(SQLcmd);
    SQLda.Fill(Results);
    //Do something with the results from the Results variable
    here.
    SQLcmd.Dispose();
    SQLda.Dispose();
    Results.Dispose();
    Connection.Close();
    Connection.Dispose();
}

```

**Example 6.5:** C# code showing how to use parameters to safely call a stored procedure.

As you can see in the above, .NET code using a parameter to pass in the value is easy to do, adding just a couple of extra lines of code. The same can be done with an inline dynamic SQL string, as shown in Example 6.6 and Example 6.7.

```

Private Sub MySub()
    Dim Connection As SqlConnection
    Dim Results As DataSet
    Dim SQLda As SqlDataAdapter

```

```
Dim SQLcmd As SqlCommand
SQLcmd = New SqlCommand
SQLcmd.CommandText = "SELECT * FROM dbo.sysjobs WHERE name=
    @job_name"
SQLcmd.Parameters.Add("job_name", SqlDbType.VarChar, 50)
SQLcmd.Parameters.Item("job_name").Value = "test"
SQLcmd.CommandType = CommandType.Text;
Connection = New SqlConnection("Data
    Source=localhost;Initial
    Catalog=msdb;Integrated Security=SSPI;")
Using Connection
    Connection.Open()
    SQLcmd.Connection = Connection
    SQLda = New SqlDataAdapter(SQLcmd)
    Results = New DataSet()
    SQLda.Fill(Results)
End Using
'Do something with the results from the Results variable here.
SQLcmd.Dispose()
SQLda.Dispose()
Results.Dispose()
Connection.Close()
Connection.Dispose()
End Sub
```

**Example 6.6:** VB.NET code showing how to use parameters to safely call an inline dynamic SQL String.

```
private void MySub()
{
    SqlConnection Connection = new SqlConnection("Data-
        Source=localhost;Initial Catalog=msdb;Integrated
        Security=SSPI;");
    DataSet Results = new DataSet();
    SqlCommand SQLcmd = new SqlCommand();
    SQLcmd.CommandText = "SELECT * FROM dbo.sysjobs WHERE
        name =@job_name";
    SQLcmd.CommandType = CommandType.Text;
    SqlParameter parm1 = new SqlParameter();
    parm1.ParameterName = "job_name";
    parm1.DbType = DbType.String;
    parm1.Precision = 255;
    parm1.Value = "test";
    SQLcmd.Parameters.Add(parm1);
    Connection.Open();
    SQLcmd.Connection = Connection;
    SqlDataAdapter SQLda = new SqlDataAdapter(SQLcmd);
    SQLda.Fill(Results);
    //Do something with the results from the Results variable
    here.
}
```

```

        SQLcmd.Dispose();
        SQLda.Dispose();
        Results.Dispose();
        Connection.Close();
        Connection.Dispose();
    }

```

**Example 6.7:** C# code showing how to use parameters to safely call an inline dynamic SQL String.

Once each parameter that is being passed into the database has been protected, the .NET code (or whatever language is being used to call the database) becomes safe. Any value that is passed from the client side to the database will be passed into the database as a value to the parameter. In the example code shown at the beginning of this chapter, the string value that has been passed into the application would then force an error to be returned from the client Microsoft SQL Server database as the value would be passed into a parameter with a numeric data type.

## Note

### Don't Trust Anything or Anyone!

The golden rule when dealing with SQL Injection is to not trust any input from the website or front-end application. This includes hidden fields and values from dropdown menus. Nothing should be passed from the front end to the database without being cleaned and properly formatted, as any value passed in from the front end could be compromised.

Hidden fields are probably the SQL Injection attacker's best friend. Because they are hidden from the end user's view and are only used by system processes, they are sometimes assumed to be safe values. However, changing the values that are passed in from a safe value to a dangerous value is a trivial matter for a script kitty, much less a skilled attacker.

When dealing with SQL Injection, the mantra to remember is never, ever, trust anything that is sent to the application tier from the end user, whether or not the end user knows that he submitted the value.

Using the sample query shown in the .NET sample code in Examples 6.6 and 6.7, if the user were to pass in similar attack code to what is shown in the SQL Server sample code in Example 6.2, the query that would be executed against the database would look like the one shown in Example 6.8. This resulting query is now safe to run as the result which is executed against the database engine contains all the attack code as a part of the value.

```
SELECT * FROM dbo.sysjobs WHERE name = 'test; delete from Orders';
```

**Example 6.8:** Sample T/SQL code showing the resulting T/SQL Code that would be executed against the database if an attacker were to put in an attack code against the prior sample .NET code.

In the sample code you can see that while the attack code has been passed to the engine, it has been passed as part of the value of the WHERE clause. However, because this is within the value of the parameter, it is safe because the parameter is not executable. If attackers were to pass in the same command with a single quote in front of it, in an attempt to code the parameter, and then execute their own code, the single quote would be automatically doubled by the .NET layer when it passed to the SQL Server database again, leaving a safe parameter value as shown in Example 6.9.

```
SELECT * FROM dbo.sysjobs WHERE name = 'test'; delete from Orders';
```

**Example 6.9:** The resulting T/SQL code that would be executed against the database when an attacker passes in an attack string with a single quote in an attempt to bypass the protection provided by the .NET application layer.

## Protecting Dynamic SQL within Stored Procedures from SQL Injection Attack

When you have dynamic SQL within your stored procedures, you need to use a double protection technique to prevent the attack. The same procedure needs to be used to protect the application layer and prevent the attack from succeeding at that layer. However, if you use simple string concatenation within your stored procedure, then you will open your database back up to attack. Looking at a sample stored procedure and the resulting T/SQL that will be executed against the database by the stored procedure; we can see that by using the simple string concatenation, the database is still susceptible to the SQL Injection attack, as shown in Example 6.10.

```
CREATE PROCEDURE sel_OrdersByCustomer
    @LastName VARCHAR(50)
AS
DECLARE @cmd NVARCHAR(8000)
SET @cmd = 'SELECT *
FROM Orders
JOIN Customers ON Orders.CustomerId = Customers.CustomerId
WHERE Customers.LastName = "' + @LastName + "'"
EXEC (@cmd)
GO
/*The command that will be executed when the attacker passed
in'; DELETE FROM Orders.*/
SELECT *
FROM Orders
```

```
JOIN Customers ON Orders.CustomerId = Customers.CustomerId
WHERE Customers.LastName = 'Smith'; DELETE FROM Orders '
```

**Example 6.10:** T/SQL stored procedure that accepts a parameter from the application layer and concatenates the passed-in value to the static portion of the string, executing whatever attack code the attacker wishes against the database engine.

Because of the value attack, the value being passed into the SQL Server Engine is passed in through the application layer, and the SQL Server engine does as it is instructed to do, which is to run the query. However, if we parameterize the dynamic SQL within the stored procedure, then the execute SQL code will be rendered harmless just as it would be if the dynamic SQL was executed against the database by the application layer. This is done via the `sp_executesql` system stored procedure as shown in Example 6.11.

```
CREATE PROCEDURE sel_OrdersByCustomer
    @LastName VARCHAR(50)
AS
DECLARE @cmd NVARCHAR(8000)
SET @cmd = 'SELECT *
FROM Orders
JOIN Customers ON Orders.CustomerId = Customers.CustomerId
WHERE Customers.LastName = '' + @LastName + ''
EXEC sp_executesql @cmd, '@LastName VARCHAR(50)',
    @LastName=@LastName
GO
/*The command that will be executed when the attacker passed in';
DELETE FROM Orders.*/
SELECT *
FROM Orders
JOIN Customers ON Orders.CustomerId = Customers.CustomerId
WHERE Customers.LastName = 'Smith'; DELETE FROM Orders '
```

**Example 6.11:** T/SQL stored procedure that accepts a parameter from the application layer and uses parameterization to safely execute the query passing whatever attack code the users input safely against the database as a simple string value.

## Removing Extended Stored Procedures

In addition to running all code from the application layer as parameterized commands instead of dynamically generated T/SQL, you should also remove the system procedures that can be used to export data. The procedures in question that you'll want to remove are `xp_cmdshell`, `xp_startmail`, `xp_sendmail`,

`sp_makewebtask`, and `sp_send_dbmail`. You may also want to remove the procedures that configure Database Mail such as `sysmail_add_account_sp` and `sysmail_add_profileaccount_sp`, so that attackers can't use these procedures to give themselves a way to e-mail out information from the database. Of course, you'll want to make sure that you aren't using these procedures in any released code and that you have Database Mail configured before removing your ability to configure it.

Of course, removing system stored procedures poses a risk of causing system upgrades to fail, so you'll want to keep copies of these objects handy so that you can put the objects back before database version upgrades.

Unfortunately, this isn't a surefire way to prevent an attacker from using these procedures. Crafty attackers can actually put these procedures back after they see that they have been removed. This is especially true of the extended stored procedures called DLLs (Dynamic Link Libraries), which must be left in their normal locations because other extended stored procedures that you don't want to remove are part of the same DLLs. The only saving grace is that you have to be a highly privileged user within the database engine to put an extended stored procedure into the SQL Server engine. Thus, the only way that an attacker could successfully put the extended stored procedures back would be to log into the database with a highly privileged account. If your application logs into the database engine using a highly privileged account, all bets are off as the attacker now has the rights needed to put the extended stored procedures back.

## Not Using Best Practice Code Logic Can Hurt You

The application login process is probably the most important one that an attacker may want to take advantage of. Many times when developers are building a login process, the front-end developer will simply look for records in a record set, and if there are none will assume that the user didn't login correctly. If there are records in the record set, the developer will assume that the user logged in correctly and so will grab the first record and use that record to find the user's permissions. Attackers wishing to exploit this situation would be able to get past the login screen, probably being logged in with a high level of permissions. This is done by adding a small text string in the username field such as "user' OR 1=1 –". What this will do is change the code shown in Example 6.12 into the code shown in Example 6.13. Example 6.14 shows the T/SQL code that would be executed against the database engine.

```
SELECT * FROM dbo.Users WHERE UserName = 'user' AND Password =
'password'
```

**Example 6.12:** The way a sample record set looks when validating a user account.

```
SELECT * FROM dbo.Users WHERE UserName = 'user' OR 1=1 - AND
Password = 'password'
```

**Example 6.13:** The way the code looks when the attack code has been inserted.

```
SELECT * FROM dbo.Users WHERE UserName = 'user' OR 1=1
```

**Example 6.14:** The executable part of the code against the database engine from the prior sample code.

Because of the OR clause in the prior sample code, it doesn't matter if there is a record where the UserName column equals user because the  $1 = 1$  section will tell the database to return every record in the database.

As you can see in the sample code above, the code that gets executed against the database engine would return the entire User table. Assuming that the front-end application simply takes the first record from the record set returned from the database, the attacker would then be logged into the application, probably with an administrative-level account. Preventing this sort of attack is easy; refer back to the beginning of this section of this chapter for the sample .NET code. Now that the user has been logged in, potentially with administrative rights, the user doesn't need to use any additional dynamic SQL to get access to your customer data, as he or she will now have full access through your normal administrative system.

## What to Return to the End User

The next important thing to configure within the front-end application is what errors are returned to the end user. When the database throws an error, you should be sure to mask the error from the end user. The end user doesn't have any need to know the name of either the primary key or the foreign key that has been violated. You might want to return something that the end user can give to customer service or the help desk so that the actual error message can be looked up.

What this has to do with SQL injection is important. If the attacker is able to send in code that breaks the query and returns an error, the error may well contain the name of a table or other database object within the error message. For example, if the attacker sends in an attack string of “ Group by CustomerId –” to a query that looks like “SELECT \* FROM Customers WHERE

UserName = 'UserName' AND Password = 'Password'" creating the query "SELECT \* FROM Customers WHERE UserName = 'UserName' Group by CustomerId - AND Password = 'Password'". The default error message that SQL Server would return gives the attackers more information than they had before. It tells them the table name. The attacker can use this same technique to figure out which columns are in the table. Over all, Being able to see the actual SQL Server error message, even if the error doesn't give the attacker any database schema information it tells the attacker that the attack attempt was successful. By using the sp\_MSforeachtable system stored procedure and the raiserror function, the attackers could easily return the list of every table in the database, giving them a wealth of information about the database schema, which could then be used in future attacks.

## Note

### Why Are SQL Injection Attacks Still So Possible?

One major reason why SQL Injection attacks are still possible today is that there is so much bad information circulating about how to protect yourself from an SQL injection attack. For example, an article published by Symantec at <http://www.symantec.com/connect/articles/detection-sql-injection-and-cross-site-scripting-attacks> says that all you need to protect yourself is to verify the inputs using a regular expression that searches for the single quote and the double dash, as well as the strings "sp" and "xp." As you can see throughout this chapter, SQL Injection attacks can occur without tripping these regular expressions, and considering the high number of false positives that looking for a single quote would give you (especially if you like doing business with people of Irish descent), the protection would be minimal at best. If you were to read this article and follow its instructions you would be leaving yourself open to SQL Injection attacks.

There is more useful information that an attacker could get thanks to the error message being returned. For example, if the users were to run a stored procedure in another database that they didn't have access to, the error message would return the username of the user—for example, if the attacker sends in an attack string "; exec model.dbo.Working -". It doesn't matter if the procedure exists or not, for the attacker won't get that far. The error returned from this call is shown in Example 6.15.

```
Msg 916, Level 14, State 1, Line 1
The server principal "test" is not able to access the database
"model" under the current security context.
```

**Example 6.15:** Error message returned by an attacker running a stored procedure that doesn't exist.

The model database is an excellent database to try this against, as typically no users have access to the model database. If the attacker gets an error message saying that the procedure doesn't exist, the attacker now knows that the login that the application is logging into the database has some high-level permissions, or the model database has some screwed-up permissions.

After finding the username, the attacker can easily enough find the name of the local database that the application is running within. This can be done by trying to create a table in the database. This is because the error message when creating a table includes the database name. For example, if the attack code “; create table mytable (c1 int);-” is sent, the error message shown in Example 6.16 will be returned.

```
Msg 262, Level 14, State 1, Line 1
CREATE TABLE permission denied in database 'MyApplication
Database'.
```

**Example 6.16:** Error message returned when creating a table when you don't have rights returning the name of the database to the attacker.

These various values can be used in later attacks to clear the database of its data or to export the data from the database.

## Cleaning Up the Database After an SQL Injection Attack

There are a few different attacks that an attacker can perform against an SQL Server database. As shown so far in this chapter, delete commands can be passed into the SQL engine. However, other commands can be executed as well. Usually, attackers don't want to delete data or take a system offline; they instead want to use the SQL database to help launch other attacks. A simple method is to identify tables and columns that are used to display data on the website that uses the database as a backend. Then extra data is included in the columns of the database, which will allow attacking code to be executed against the database. This can be done using an update statement that puts an HTML iframe tag into each row of a table. This way when customers view the website, they get the iframe put into their web browser, which could be set to a height of 0 so that it isn't visible. This hidden iframe could then install viruses or spyware on the user's computer without their knowledge.

## FAQ

### IFRAME versus PopUp

Often people ask if a popup blocker would prevent this iframe attack from affecting the end user, and the answer is no, it wouldn't. An iframe doesn't show a web browser popup on the users screen. An iframe is an inline frame which shows within the displayed webpage. An iframe with a height of 0 would be totally invisible to the end user, but it could be requesting data from a webpage on another website, passing information from the user's computer back to this unknown website. The website that is called from the iframe could then exploit vulnerabilities in the end user's web browser to install key loggers or command and control software turning the end user's computer into a member of a bot-net.

Once this attack has occurred and viruses or spyware have been installed on the customer's computer, the most important thing now is to stop additional users' computers from being attacked. This means going through every record of every table looking for the attack code that is pushing the iframe to the customer's web browser. Obviously, you can go through each table manually looking for the records in question, or you can use the included sample code, shown in Example 6.17, which searches through each column in every table for the problem code and removes it. All you need to do is supply the variable with the attack code. The only columns that are not cleaned by this code are columns that use the TEXT or NTEXT data types. This is because the TEXT and NTEXT data types require special attention as they do not support the normal search functions.

```

DECLARE @injected_value NVARCHAR(1000)
SET @injected_value = 'Put the code which has been injected here.'
/*Change nothing below this line.*/
SET @injected_value = REPLACE(@injected_value, '"', '""')
CREATE TABLE #ms_ver (indexid INT, name sysname, internal_value
    INT, character_value VARCHAR(50))
INSERT INTO #ms_ver
EXEC xp_msver 'ProductVersion'
DECLARE @database_name sysname, @table_schema sysname,
    @table_name sysname, @column_name sysname, @cmd NVARCHAR
    (4000),
@internal_value INT
SELECT @internal_value = internal_value
FROM #ms_ver

```

```

DECLARE cur CURSOR FOR SELECT TABLE_CATALOG, TABLE_SCHEMA,
    TABLE_NAME, COLUMN_NAME
    FROM INFORMATION_SCHEMA.columns c
    JOIN systypes st ON c.DATA_TYPE = st.name
    WHERE xtype IN (97, 167, 175, 231, 239, 241)
OPEN cur
FETCH NEXT FROM cur INTO @database_name, @table_schema,
    @table_name, @column_name
WHILE @@FETCH_STATUS = 0
BEGIN
    SET @cmd = 'SELECT NULL
    WHILE @@ROWCOUNT <> 0
    BEGIN
        IF @internal_value > 530000
            SET @cmd = @cmd + ' SET ROWCOUNT 1000
        UPDATE'
        ELSE
            SET @cmd = @cmd + ' UPDATE TOP (1000)'
        SET @cmd = @cmd + '[' + @database_name + '].[' + @table_
            schema + '].[' + @table_name + ']'
        SET '[' + @column_name + ']' = REPLACE([' + @column_name + ']', '
            ' + @injected_value + '", '')
        WHERE '[' + @column_name + ']' LIKE '%" + @injected_value + "%'
    END'
    exec (@cmd)
    FETCH NEXT FROM cur INTO @database_name, @table_schema,
        @table_name, @column_name
END
CLOSE cur
DEALLOCATE cur
DROP TABLE #ms_ver

```

**Example 6.17:** T/SQL Code that will clean a database that has had its values updated to send unvalued code to users.

## Note

### Notes About Using This Sample Code

Before running the included T/SQL code, be sure to make a full backup of the database in case of accidental data modification. The larger the database that you run this against, the longer it will take. When running this sample code, it is recommended that you change the output type from the default output style of grid to text by pressing <CTRL>+T, in order to reduce the resources needed to run the query. The included code will execute against all versions of Microsoft SQL Server from version 7 to 2008 R2.

## Note

### SQL Injection is Serious Business

In case you hadn't guessed after reading this chapter, SQL Injection attacks are a very serious threat. Normally when an SQL Injection attack is launched, it isn't launched against a single website. An attacker will often write a program that will check as many websites as possible before the attacker is taken off the Internet. The last successful large-scale attack on the Internet (as of the writing of this book) successfully changed the data in tens of thousands of separate databases that run tens of thousands of different websites. At the time of the attack, this was verified by searching on Google for the text of the code that was inserted into the attacked databases and looking at the number of domains that Google returned with matches.

Falling prey to these attacks puts users and customers at major risk, as these attacks often are trying to install viruses or Trojan horses on the end user's computer, so that confidential data such as credit card numbers, and banking usernames and passwords can be gathered by the attacker and used to commit future fraud against the users and customers of the attacked websites. This can lead to months or years of credit report problems and the like.

One final point to keep in mind: If you use your own company's websites or services, then the SQL Injection attacker is attempting to attack you as you are also a customer. So do yourself a favor and protect the database so that you don't get viruses or Trojan horses installed on your computer through your own company's website.

## Summary

SQL Injection attacks pose some of the greatest dangers to the database and customers because they are typically used to directly affect the information that the customer sees and can be rather easily used to attempt to push malicious code to clients' computers. These attacks are very popular with attackers because they are a relatively easy way to exploit systems design. They are also popular because they are easy to reproduce once a site is found to be compromisable, as it usually takes a long time to correct all the potential attack points in a website. This length of time leaves the website and database open to attack for a long period of time as companies are usually unwilling to shut down their customer facing websites while the website design is being repaired.

Because of the way that the SQL Injection attacks work, the Database Administrator, Database Developer, Application Developer, and Systems Administrator all need to work together to ensure that they are correctly protecting the data within the database and the company network at large. As the database and application developers begin getting in the habit of writing code that isn't susceptible to SQL Injection attacks, the current project

will become more secure, as will future projects that the team members work on.

SQL Azure is just as susceptible to an SQL Injection attack as any other SQL Instance. What the attacker can do within the instance is much less dangerous simply because there are many fewer features available. For example, protection against `xp_cmdshell` isn't a priority because `xp_cmdshell` isn't available on an SQL Azure instance. Neither are features such as database mail or SQL mail, so protecting against attackers that plan to use these vectors doesn't need to be done. As time goes on, and more features are added to SQL Azure, this may change; however, as of this writing, this information is accurate.

## References

"Wall Street Journal, Others, Hit in Mass SQL attack—SC Magazine US." *IT Security News and Security Product Reviews—SC Magazine US*. N.p., n.d. Web. October 21, 2010.